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Luca Tateo

A Theory of Imagining, Knowing, and Understanding

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To my daughter Gaia

Series Editors' Preface

Theory of Imagination and Imagination of a Theory

Luca Tateo has undertaken a task that has remained undone for a century. Psychology over the last hundred years—after Hans Vaihinger (1911) powerfully pointed out how "useful fictions" are needed for the human mind—has remained mute on the role of imagination in the human psyche. The ever-active efforts toward anchoring psychology in the realism of the phenomena *as these are* have de-focused the researchers from the linked developmental question—phenomena *as they could be*, or *could become*. Of course that question can be answered in the present time only through imagination. Thus, imagination can be understood as the central arena for human psychological functioning.

Since ancient times, imagination has occupied a special position in any theory of human knowledge. Already at the first inspection, imagination highlights as the faculty of producing new images (or *phantasmata*), indispensable for making possible the specifically human mode of knowledge. In animals, knowledge capacities are essentially restricted to the data provided by the senses. Animal behavior is constrained to an organism's repertoire in front of salient features of its environment. Feeding, sleeping, hunting, fleeing, and mating are, in animals, determined by surrounding sensorial stimuli. In the human case, higher complexity processes interrupt the straightforward dependence on sensorial data. One of these higher level processes is imagination. It detaches people from their immediate surroundings, allowing them to act with regard to internally produced stimuli rather than externally given occurrences. Imagination operates by transforming and altering images provided by the senses, allowing new modes of perception and breaking the fundamental action-reaction of animal life. Imagination produces modified sensorial data, providing images for higher intellectual tasks such as reasoning and language production. In this sense, imagination occupies a middle position between the senses and intellect; it can be understood as either the highest sensory modality—the Aristotelian *sensus communis*—or the lowest intellectual process.

In the Hellenistic tradition, the peculiar intermediate position of imagination results in its oscillating consideration between *psyche* and *nous*. On the one hand, imagination works when people dream, providing images that populate sleeping minds. Thus, imagination seems to work independent of conscious, goal-oriented rational thinking. From this point of view, imagination is seen as tightly united to vital forces and therefore one of the multiple functions of *psyche*. On the other hand, imagination represents the most basic intellectual operation upon sensory perception, initiating the properly human rational approach to nature. Imagination seems to be an indispensable part of every form of noetic examination of reality, from the abstract counterfactual thinking ("*What if this or that were the case?*") to the vivid understanding of poetic images. Thus, imagination is matter and form; part of the sensible world, part of the spiritual world.

In modern times, imagination also plays an intermediate role in knowledge. Imagination is situated between affect and cognition as well as between unconsciousness and consciousness. At the dawn of the nineteenth century, imagination, in the form of *fantasy*, was an important soul faculty whose existence allowed the contact with the totality of Nature. Its cultivation was necessary for whoever was interested in knowing Nature. Rational means are not enough; it is also necessary to *feel* Nature. We need, in Goethe's terms, "the exact sensory fantasy" (see Cornejo, 2017a). *Fantasy* is hence incorporated into "passive faculties," whose cultivation should compensate what rationality and understanding cannot reach. Far from being a mechanism to get away from the mundanity of the real world, Goethean anthropology and the school of thought he inspired understood fantasy as having *epistemic value* (Cornejo, 2017b): it corresponds to the necessary process of bringing abstractions and discursive thinking to the soil of Earth. Opposing the rational model of human mind, which at that time gained increasing notoriety, fantasy and imagination is understood by Goethe as being central for *knowing* Nature. It is impossible according to him to really understand Nature without the human capacity to feel within oneself the texture of life. The concept of the mind as a rational calculus device expanded rapidly through the nineteenth century alongside a natural sciences worldview. In such a framework, affects and feelings do not play any role in knowledge. Inversely, affects (e.g., as Descartes' "passions") hinder the clear and rational analysis. Imagination becomes reduced to a mechanical process, submissive to the task of objective knowing. This reduced and dispassionate version of imagination has become the current vision in psychology.

In this monograph, Tateo presents a new approach to imagination. Tracing back the term to its rich pre-logical (and thus, mythical) roots in antiquity, he recovers its epistemic function not only in art and literary expression but most importantly for the express purposes of this volume in scientific thinking. Instead of insisting on the inherited antithetical counterpoint *factic language* versus *poetic language*, wherein the first is plain and objective while the second is expressive and subjective, Tateo reveals to us the hidden imaginative powers implied in scientific inquiry. Special attention is granted to the useful sociocultural device of *Gedankenexperiment (*mental experiment) whose pervasiveness in analytical philosophy and numerous sciences disciplines often hides an imaginative essence. Science, Tateo convincingly

argues, is driven by the imaginative power of the human mind. Because no clear-cut border between scientific objective and poetic subjective can be traced, thus a model emerges within which *imaginative and non-imaginative elements* merge permanently in rational discourse.

As a consequence of his model, Tateo advocates for a *pedagogy of imagination*. In the tradition of Northrop Frye (1964) and William Walsh (1960)—and even before them, Friedrich Schiller—Tateo rekindles the plea for an integral pedagogy, where not only skills in reasoning and logic but also imaginative capacities are educated. Novelty in science (as in any given intellectual activity) is intentionally produced by means of abductive processes, which are essentially different from deductive and inductive ones. This point is incidentally relevant since it remembers that any theoretical framework has practical consequences guiding our perceptions and actions—and even more when they live implicit in our instituted norms. Imagination is the road to personal freedom—as well as a necessary starting point to construction of new theories in a discipline that often suffers from a perceived overreliance on empirical science. The road to true integration of the empirical into science in psychology goes through theoretical creativity, and this book is a very appropriate example.

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Luca Tateo is visiting associate professor at the Federal University of Bahia. He is associate professor at the University of Oslo, associate professor at the Centre for Cultural Psychology at Aalborg University (20%), and honorary associate professor at Sydney University. He is editor in chief of the book series "Innovations in qualitative research," Information Age Publishing, and co-editor in chief of the journal *Human Arenas. An Interdisciplinary Journal of Psychology, Culture, and Meaning*, Springer. He is part of the "Kitchen Seminars" network and of the IBEF—International Centre "Ideas for the Basic Education of the Future." His wide range of interests goes from the epistemology and history of psychology to the method of art as exploration of human experience and from the study of imaginative processes to the development of the Self in educational contexts.

Chapter 1
Introduction: The Myth of *Hippocrene*

This is a book about imaginative work and its relationship with the construction of knowledge. So far so good. It is nowadays fully acknowledged by epistemologists that imagination is not something opposed to rationality; it is not mere fantasy opposed to intellect. In philosophy and cognitive sciences, imagination is generally "delimiting not much more than the mental ability to interact cognitively with things that are not now present via the senses" (Stuart 2017, p. 11). For centuries, scholars and poets have wondered where this capability could come from, whether it is inspired by divinity, or whether it is a peculiar feature of human mind (Tateo 2017b).

The omnipresence of imaginative work in both everyday and highly specialized human activities requires a profoundly radical understanding of this phenomenon. We need to work imaginatively in order to achieve knowledge, and thus imagination must be something more than a mere flight of fantasy. Considering different stories in the field of scientific endeavor, I will try to propose the idea that the imaginative process is a fundamental higher mental function that concurs in our experiencing, knowing, and understanding the world we are part of. This book is thus about a theoretical idea of imagining as a constant part of the complex whole we call the human *psyche*. It is a story of human beings striving not only for knowledge and exploration but also for imagining possibilities.

As all good stories, it has a "once upon a time" beginning, in search of the ancestral acknowledgment of the value of imagining. There is an ancient Greek myth, appearing for the first time in Hesiod's *Theogony* (Most 2006), that narrates about the *Hippocrene*, literally the "horse's spring." The myth is based on the figure of *Pegasus* (Fig. 1.1) and provides a very complex symbolism about the relationship between imagination and knowledge. *Pegasus* was the winged divine stallion, born from the blood flowing off the beheaded body of *Medusa*, killed by *Minerva*'s protected hero *Perseus*. The image of Pegasus is full of symbolic power. It "is indeed

This chapter is based on the inaugural lecture "Human Sciences and imagination: present challenges to knowledge and research" (Ciências Humanas e imaginação: desafios do conhecimento e da pesquisa na atualidade) which was given at Federal University of Bahia on April 19, 2018.

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Fig. 1.1 Pegasus. Attic red-figure squat lekythos from Sicily, 480–460 BC, public domain, https://commons.wikimedia.org/w/index.php?curid=3009626

almost a figure for Minerva, like her symbolizing the inventive power of the mind, and sprung fully-formed from the (blood of the) Gorgon's head, just as she sprang fully-armed from the head of Jupiter" (Trapp 2012, p. 253).

Pegasus is a wild horse, though, which was donated to Zeus, who used him to carry his lightnings and thunders from the *Olympus*. *Pegasus* is also a friend of the *Muses*, and it used to live on the Mount *Helicon*. The version of the myth by the Latin poet Ovid narrates that one day the nine daughters of the Macedonian king *Pierus* decided to defy the *Muses* in a song context (Hinds and Stephen 1987). The *Pierides* were defeated and transformed into birds, as it always used to happen to those humans who dare to challenge the gods. However, during the context, the beauty of the song of both parties, the *Muses* and the *Pierides*, was so wonderful and mesmerizing that the Mount *Helicon* itself started to heave and grow, almost reaching the *Olympus*. At this point, *Pegasus* hit the *Helicon* ground with a blow of its hoof to prevent it from growing further. At the point where the hoof hit the ground a water source sprang. The new spring was called *Hippocrene*, and the *Muses* used to drink and dive in its waters to find inspiration (Hinds and Stephen 1987).

The myth of *Hippocrene* creates a very interesting link between different forms of knowledge, inventions of the mind, and artistic creation. It contains so many symbolisms and relationships with other myths that it would be impossible to discuss them all in a single chapter (Crowther 1979; Hinds and Stephen 1987; Trapp 2012). I will limit myself to the themes that are strictly related to the relationship between imagining and knowing as fundamental activities of the human mind.

Pegasus represents the transformation of the obscure and uncanny power of mind, represented by the *Gorgon Medusa* with her petrifying gaze, into the creative power of

mind after the intervention of *Minerva*'s protégée *Perseus*. At this point, *Pegasus* becomes the symbol of imagination, whose power can produce art if properly educated, as in the domestication made by *Zeus* and further refined by *Minerva*, who creates special gold bridles that allow *Bellerophon* to ride the winged horse in another part of the myth, and kill the monster *Chimera*. *Pegasus*, once semidomesticated, lives on the Mount *Helicon* and becomes friend of the *Muses*. The nine daughters of *Zeus* and *Mnemosyne*, Titan goddess of memory, are the inspirational goddesses of literature, science, and arts. The myth thus establishes a first interesting relationship between the inventive power of the mind and the different forms of human knowledge. Besides, the myth recalls the iconography of the water spring as a metaphor of poetic inspiration (Crowther 1979) and the origin of the rhythmical verse in ancient poetry, also called *pedis ictus*, from the rhythm of the horse's hoof (Hinds and Stephen 1987, p. 17).

The theme of *Hippocrene* has survived along the centuries (Fig. 1.2), and has been associated with the mighty power of inspiration in art. However, the progressive restriction of the meaning of the *Muses* to what we called today the humanities has overlooked the fact that in Ancient Greek's epistemology, the distinction between art and science was different and not so sharp. The attempt to build a rigid hierarchy of knowledge is indeed dated back to Plato and Aristotle, and is thus relatively younger with respect to the cosmology and mythology of the *Muses*.

Fig. 1.2 Helicon or Minerva's Visit to the Muses, by Joos de Momper the Young, seventeenth century—collection of Koninklijk Museum voor Schone Kunsten Antwerpen, www.latein-pagina.de, public domain, https://commons.wikimedia.org/w/index.php?curid=10455189

In 1819, poet John Keats still referred to *Hippocrene* in his poem *Ode to a Nightingale*:

> O for a beaker full of the warm South
> Full of the true, the blushful Hippocrene,
> With beaded bubbles winking at the brim,
> And purple-stained mouth;
> That I might drink, and leave the world unseen,
> And with thee fade away into the forest dim (Keats 2017, p. 108)

The fate of the myth of *Hippocrene* reflects the general trajectory of the understanding of imagination in the Western history of ideas, including the movement of both re-appreciation of this faculty and, at the same time, its restriction to the realm of artistic creativity (Tateo 2015a, 2016a). The *Hippocrene* is indeed the place where inspiration is reinforced not only for poetry, but also for other forms of knowledge, such as history, mathematics, and astronomy. Moreover, we do not have to forget that the *Muses* are daughters of *Mnemosyne* and that *Pegasus* originates from the obscure recess of *Medusa*. So, the myth also evokes the relationship between imaginative power and different forms of remembering, both conscious and constructive and unconscious and instinctual. The persistence of the myth is posing some fundamental questions as follows: What is exactly the nature of imaginative power, insight, and inspiration that operate in the construction of knowledge? How imaginative work and knowledge creation are related?

Epistemic Value of Imaginative Processes

The mythology is always an important source of reflections. It signals the ancestral origin of some fundamental philosophical, psychological, and existential problems. Myth also provides a rich repertoire of images, analogies, and connections that inspire innovative thinking. So, in this essay, I let inspiration from *Hippocrene's* myth to develop my initial reflections about the epistemic value of imaginative processes.

Imagination is no longer a business of poets, painters, and daydreamers:

> Partially thanks to the growing influence of science studies since the 1960s, many philosophers and cognitive scientists have reversed this trend, and now see the imagination as an important factor in the production of knowledge and other epistemological desiderata. (Stuart 2017, p. 10)

Philosophy is nowadays rediscovering the epistemic value of imaginative work, which was well acknowledged in humanism and later on by Giambattista Vico (Tateo 2017b), and later dismissed by Cartesian rationalism. Richmond (1984) illuminates the complementarity between artistic and scientific modes of knowing and expressing meaning:

> Science (the institutional structures and social constructions that guide the activities of individual scientists) destroys the products of imagination, the worlds created or inspired by

> artists. Art (the institutional structures and social constructions that guide individual artists) revives and refreshes imagination. Art provides science with an ocean of inarticulate problems and ideas. Science uses these as inspiration for articulate problems and ideas for critical examination. I return to the correspondences mentioned earlier to illustrate this interdependence of science and art. Modern science and art provide articulate and inarticulate discussions, respectively, of the cosmological problem, Where are we? The Aristotelean imagination became petrified in the astrology of pre- Renaissance civilization. Aristotle's theory of motion came under the criticism of late medieval philosophers. These events allowed the imaginations of Brunelleschi and Dürer to stir scientific intuition to develop a new image of the universe. When this image became ossified in nineteenth-century academic art, the criticism by Mach and Poincare of Newtonian space released the imagination to develop a new image of the cosmos. The imagination-stretching work of the pioneers of film and the Impressionist-Cubist forerunners of twentieth- century painting indirectly stimulated the scientific intuition of Einstein (Richmond 1984, p. 84).

In few lines, Richmond draws the sociohistorical process through which art and science feed into each other, despite the progressive specialization and division between the two realms that will take place from the Enlightenment onward.

By epistemic value (Haddock et al. 2009), in a wide sense, I mean the generative capability of imaginative processes to produce richer forms of knowledge, understanding, ideas, hypotheses, intuitions, anticipations, and simulations about oneself and the world one is part of, including both the proximal (in one's own same space-time) and the distal (in a different or distant space-time) experiences. In the history of sciences, several modes of thinking that can be related to imaginative processes have played a major role, as I will show in the next chapters. Thus, I argue that it is important in the education of future scholars to take into account the epistemic value of imaginative work, both in basic and applied research. For this sake, I establish a dialogue with four main sources: the philosophy of imagination developed by Maria-Noel Lapoujade (1988, 2018), who first talked about *homo imaginans*; the history of imagination by Dennis Sepper (2013); Leslie Stevenson's intensive and extensive discussion of the many ways to understand imagination (2003); and my own works on epistemology (Tateo 2013, 2014, 2015b, 2016b) and imagination (Tateo 2015a, 2016a, 2017a, 2018). I use the terms "imaginative process," "imagining," "imaginative work," or "imaginative activity," rather than "imagination," "understood as object," "content," or "product of an activity." I argue indeed that imagining is a fundamental higher mental function (Tateo 2015a, 2016a) at work in everyday as well as scientific modes of thinking[1] (Holton 1998). Imagining is thus a part of psychic life and it has its historically situated sociogenesis and ontogenesis.

[1] It could also be argued that imagining is a modality in which higher psychological functions can sometime operate (Vaihinger 2014). For instance, according to Zittoun and Gillespie (2015) imagination is a mode of thinking that relates to distal experiences. So, one can think in "reality" modality but at times can "loop out" and shift to imaginative modality (Zittoun and Gillespie 2015). It sounds to me an idea of imagination as a "sandbox" to test "modal propositions by seeing whether they are conceivable, or produces psychological states which obey special norms" (Stuart 2017, p. 11). Although the idea of imagination as an "as-if" mode of experiencing fits with my idea of imagining as a process that involves the body-mind as a whole, I still think that we need to acknowledge the presence and the role of imaginative work in a number of different instances.

Leonardo's Imagination

If we want to go back to a time in which imagining and knowing were not separated, we probably need to visit the Italian Renaissance. We can point to an iconic scholar like Leonardo da Vinci (1452–1519). He was of course a genius, but not one of its kind with respect to the relationship between imaginative and empirical modes of knowing. Indeed, he completely shared the natural philosophy of his times:

> Poetic speculation and fantasy, for Leonardo, was founded on a bedrock of natural causes and effects. This was not intended to limit the exercise of fantasy or the scope for invention. (Kemp 1985, p. 206)

What makes Leonardo even more interesting is the fact that he left a number of documents about his artistic and scientific work, today spread in a number of collections (*codex*) around the world. In those documents we can observe the mutual feeding of the different modes of experiencing (imaginative and non-imaginative) into the elaboration of new knowledge.

Aristotle claimed that imagination is the production of phantasma, pre-worked representations of senses and impressions that can be used by the intellect to form ideas. This led to the idea that we cannot imagine but starting from the previous experience. Thus, a mythical creature like *Pegasus* could be imagined only by starting from the combination of old material (e.g., an image of a horse and an image of a bird) into new combinations.

But Leonardo da Vinci shows a more complex relationship between experience and imagination. Let us take from his codex the example of another mythical animal: the dragon. Leonardo was preparing some sketches of a painting of Saint George and the dragon. He left some reflections and drawings about how to compose the infernal monster (Fig. 1.3). He stated that a monster could only exist or have existed if it was formed in obedience to natural law. So, the creature should be based on a compound of parts from animals known to exist in nature, to provide a repertoire of forms which have been so designed:

> Thus, when we look at one of his marvelously compelling sketches of dragons, we sense an understanding of animal structure and motion which raises it far above the heraldic commonplace of dragons in fifteenth-century art. (Kemp 1985, p. 207)

In Fig. 1.3 we have an example of the direction from non-imaginative work (the empirical observation of existing animals) to imaginative work (the creation of an accurate model of a non-existing creature). However, in Leonardo, imaginative and non-imaginative works complement each other in a richer way. If we observe the sketch of a flying machine in Fig. 1.3b, we can see that the ideation is a rich combination of both the empirical observation of animal anatomy and the imaginative work that led to the creation of the dragon figure in Fig. 1.3. Renaissance's natural

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Imagining is at stake both in everyday life and in specialized activities such as science. In the following chapters, I provide the example of imaginative activity as a form of knowledge about past and future, in scientific research and art, at individual and collective level.

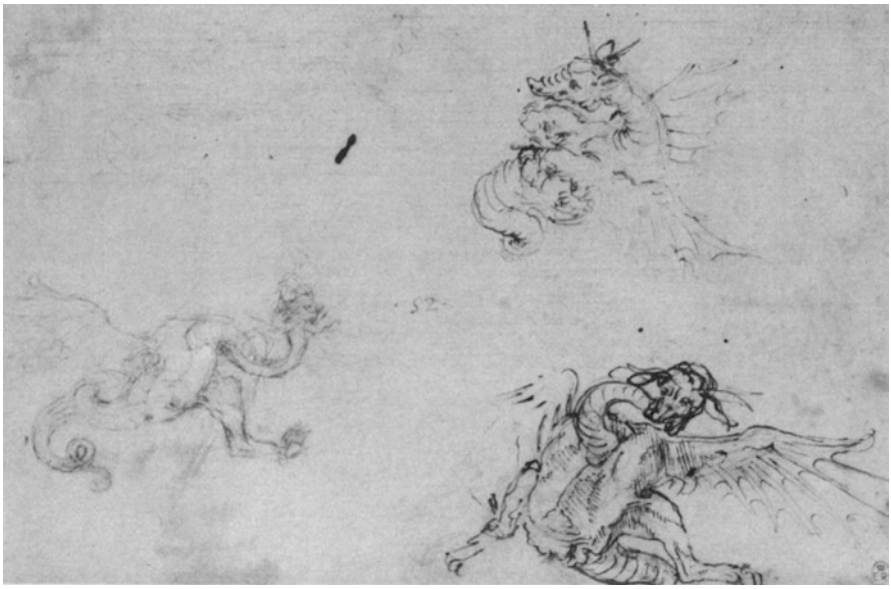

Fig. 1.3 (**a**) Leonardo da Vinci, Studies of Dragons (Windsor Royal Library 12370r, in Kemp 1985, p. 206) (**b**) Design for a flying machine, by Leonardo da Vinci—http://www.drawingsofleonardo.org/, public domain, https://commons.wikimedia.org/w/index.php?curid=3559365

philosophy is a complex whole of connections between imaginative and non-imaginative forms of experience. One can see how the distinction is no longer between empirical and imagined, to the extent that the former feeds into the latter, allowing to "see in the bared heart of a fish the thudding of a mechanical pump. In each case they perceived an analogy unnoticed up till then" (Jacob 2001: 119). In the way of experiencing of Leonardo:

> despite the very different means of expression used by the poet and the scientist, imagination works in the same way. It is often the idea of a new metaphor that guides the scientist. An object, an event, is suddenly perceived in an unusual and revealing light, as if someone abruptly tore off a veil that, till then, had covered our eyes. (Jacob 2001: 119)

It is the complementarity between imaginative and non-imaginative modes of experience that allowed Leonardo to conceive and design a number of astonishing inventions ahead of his time (Fig. 1.4).

People are nowadays fascinated by the capability of Leonardo to conceive ideas that seemed to be centuries ahead of his time, while common sense nowadays. However, what we call "visionary" capability is not an isolated manifestation of a "genius," rather the result, as I will try to maintain in the next chapters, of a combination between imaginative and non-imaginative modes of thought. On the one hand, imaginative work feeds into empirical work (the dream to fly leads to studying the physics of flight). On the other hand, the empirical work expands the possibility to imagine new directions.

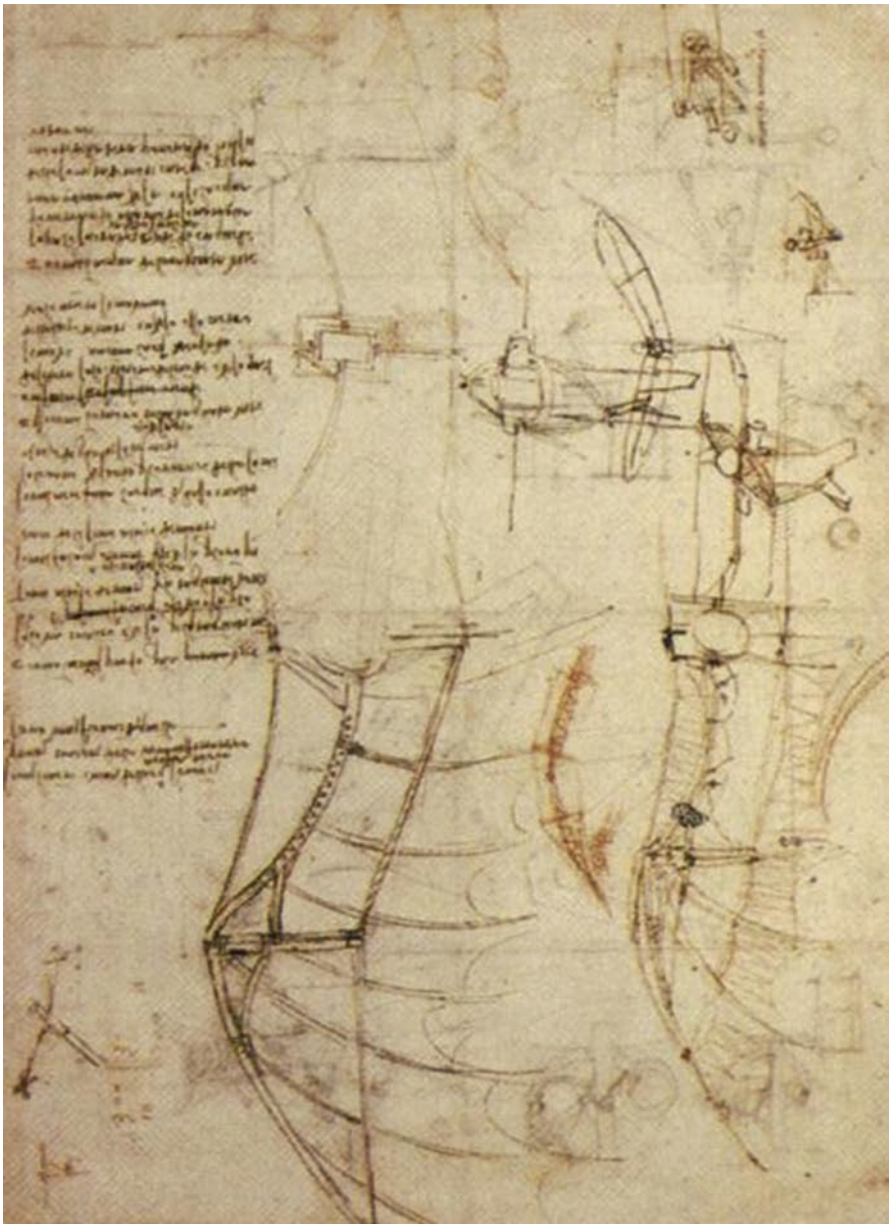

Fig. 1.3 (continued)

Fig. 1.4 Two models from Leonardo's original projects: a flying machine (on the left) and a projector of images (on the right)

Thanks to Leonardo's sketches and diaries, we know that he recognized this process as a special form of inventive imagination or fantasia. He adopted the view of the medieval faculty psychology, which assigned different mental capacities to each of the ventricles of the brain (Fig. 1.5).

In the Aristotelian tradition of psyche, Leonardo adopted the topology of mental faculties in the ventricles of the brain. They were divided into sensuous perception (Imprensiva); rational faculties, or "inner senses" (Sensus Communis/Fantasia/Intelletto); and memory. Fantasy (or imagination) was considered somehow in between the senses and the intellect (see Fig. 2 in the next chapter), with the task of combining images to make new compounds, inventing endless permutations on the raw data of sense impressions. Leonardo developed this idea in line with his natural philosophy:

> He explained that 'nature is concerned only with the production of elementary things, but man from these elementary things produces an infinite number of compounds'. Where he departed from the medieval norm was in his location of fantasia in the second ventricle rather than the first. The ventricle was the home of rational intellect and seat of the soul. Fantasia was thus moved to the centre of mental activity, and could accordingly act in close liaison with the higher powers of thought. (Kemp 1985, p. 208)

There is another common element that unites all the three different modes of knowing in Leonardo's work (empirical, imaginative, and ideational). If one looks carefully at his drawings of the bird's wing, the dragon and the flying machine, one can experience that there is a common grounding feeling: the striving for the new.

Fig. 1.5 Sections of the human head, showing the three ventricles: "Imprensiva"; "Sensus Communis/Fantasia/Intelletto"; and "Memoria" (Windsor Royal Library 12370r, in Kemp 1985, p. 209)

I think that this is an overlooked power of imaginative work: it is by definition the mental function that orients toward the future and the external or internal edges of our familiar experiences. It is surprising how this feature has been overlooked by those who considered imagination just as a combinatory capability, rather than a motivational source.

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Chapter 2
A Glance on the Imaginative Processes

My purpose is to develop the understanding of imaginative work as higher mental function. This implies some axiomatic assumptions: it is a meaning-making semiotic process (Valsiner 1994), and it is intentional, teleological, and teleogenetic.

Imagining is an intentional act, in the sense that it is not a mere reaction to environmental conditions and it is distinguished from states of altered consciousness like dreaming, although they share some elements. So, imagining is a purposeful action accomplished in function of a future-oriented goal. Yet, at the same time, imagining is moving the edge of experience toward the future, so that it has the capability of generating new conditions leading to the emergence of new goals. As in the case of the other higher mental functions, we do not *undergo* them—rather, we purposefully use them as a whole, through cultural mediation—to produce goal-directed meaningful conducts (or to inhibit conducts, which is as meaningful), which in turn will lead to the emergence of new goals.

Thus, I need to explore the different ways we imagine to make sense of what happens, what happened, and what will, should, or must happen: in other words, how imaginative work supports the production of judgments and plans about past, present, and future. I begin by briefly introducing the different conceptions of imagination, their implications, and limits and then present my own view. Afterwards, I discuss the relationship between imagining and knowing both in everyday life and in science. I present examples of different types of works of imagination in social, human, and natural sciences: from thought experiments to metaphors and utopias. Finally, I will introduce some possible future (imaginative) pathways along which we can develop research about sociogenesis and pedagogy of imaginative processes that can become useful for both human and natural sciences.

L. Tateo, *A Theory of Imagining, Knowing, and Understanding*, SpringerBriefs in Psychology, https://doi.org/10.1007/978-3-030-38025-0_2

5000 Shades of Imagining

I could not help pointing at one of the less imaginative, though popular, best-seller books of the decade (James 2011). First of all, because it immediately breaks down the stereotypical relationship between imagining, creativity, and art (Sepper 2013; Tateo 2017). It shows how even the narrative of the most risqué and unavowable sexual fantasies can reveal to be tremendously banal. The novel talks about a young naïve girl who meets a rich and perverted young businessman, who incapable of feelings can express himself only through sadist sexual practices. So far, nothing particularly creative, but the story goes on with the initiation of the young girl to her role of subject until she develops into the dominant partner and teaches love to the man. The banal story of intimacy is sold through the appeal to sexual imagination, represented by the sadist practices and a number of sex toys. The imitator of Marquis de Sade soon reveals to be a pink literature writer, and the reader realizes that there is no revolutionary charge in the novel.

Secondly, I cannot avoid thinking that 50 shades of gray is not a great deal of imagination. What about trying to imagine 5000 or infinite shades? Or what about imagining one single shade? The latter case would be paradoxical; it could be understood as an oxymoron. After all, how we can have "shades" in the presence of a single chromatic instance? This leads us directly to one of the interesting things we can do with imagination.

I have assumed that imagining is a mental process, an activity which is not identifiable with a product. Imagining is not limited to the production of things that are absent here and now. Imagining is an activity involved in promoting or inhibiting meaning-making. In the case of James' novel, there is some imaginative work in place, like in any form of sexual intercourse, but in this case, the imagining person is not particularly creative, rather inhibiting richer imaginations. One can imagine to be banal!

On the other hand, imagining is fundamental in expanding the field of experience (Vygotsky 2004). A fundamental part of knowledge creation is due to the fact that we can imagine to violate the rules of empirical reality and classical logic (Lapoujade 1988). However *50 shades of gray* fails in trying to imaginatively violate the rules of boring sexuality and expand the experience of intimacy. This leads to the third reason for playing with James' novel: it immediately reminds me of a more interesting example: Hume's blue (Sepper 2013, p. 55). In one famous passage of *An enquiry concerning human understanding* (Hume 1748/2016), quoted by Sepper (2013), David Hume discusses a thought experiment about the relationship between sense, memory, and imagination. He invites the reader to imagine a person with 30 years of experience in every shade of blue, who, by observing the arrays of shades from the darkest to the lightest, realizes that there is a gap, a space for a further (and so far unseen) shade of blue:

> Now I ask, whether it be possible for him, from his own imagination, to supply this deficiency, and raise up to himself the idea of that particular shade, though it had never been conveyed to him by his senses? I believe there are few but will be of opinion that he can:

> and this may serve as a proof that the simple ideas are not always, in every instance, derived from the correspondent impressions; though this instance is so singular, that it is scarcely worth our observing, and does not merit that for it alone we should alter our general maxim. (Hume 1748, ch. 2, par. 8)

Hume does not develop this experiment much further, yet the issue is extremely relevant to understand the role of imagining in science. According to Sepper (2013), in the presence of such a kind of missing instances—no matter how many years of experience one has, how many shades are missing, or which sensory modality it is about (colors, tones, patterns, rhythms, etc.)—one would start imagining the possibilities of filling the gaps (Pelaprat and Cole 2011). The first consequence we can draw from this example is that "[i]magination would thus not be reproductive only; it could actually produce a new idea, one that does not directly correspond to any previous impression" (Sepper 2013, p. 57). Since the beginning, imagination has been indeed understood as something in between the senses and the intellect (Lapoujade 1988; Sepper 2013). It was the faculty of creating an attenuated representation of sense impressions—fantasy comes from the ancient Greek *phantasma*—and providing a pre-worked material that could be stored in memory and used by intellect to work out ideas. On the other hand, once this reproductive faculty has created mental images, these can be recombined in numerous ways to originate infinite new combinations, from centaurs to three-headed dogs, and from dragons to top models. The distinction between reproductive and productive imagination has resisted over centuries, at least until Kant (Lapoujade 1988; Sepper 2013). Yet Hume's example is providing us with a different instance: an imagination which is not based on any previous sense impression. In the case of the "shades of blue," imagination is used in a "generative" way (Tateo 2015, 2016). Imaginative work has both an analytic and synthetic capability: an idea is produced that is originated in an absence, a gap, but at the same time an analogy and a memory, a pattern that includes a not-yet existing instance.

The starting point for science is exactly a "gap feeling," an acknowledgment of a missing instance in the phenomenal world or in our models and theories (and even in our desires); we can realize that the case presented by Hume—probably trying to describe the exception that confirms the skeptical empiricism's rule—is instead a nice example of the role of imaginative processes in scientific work. To illustrate the importance of "gap feeling" in science, I will now introduce the story of another fundamental advancement in chemistry.

From Shades to Periodic Table of Elements

In 1860, in Karlsruhe in Germany, the international congress of chemistry was organized with the ambitious goal of achieving a precise definition of the fundamental concepts (e.g., atom, molecule, alkalinity) and establishing a plan for a rational nomenclature. There was a huge collective effort to reach a unified understanding of chemistry principles, and to find the constitutive elements of chemistry, in a time

when atomic theory was only at the beginning and not yet available as a solid base. Mendeleev was one of the scientists committed to the endeavor of understanding chemical phenomena in the absence of a *visible* basic constituent, but knowing its existence.

One can understand Mendeleev's process of progressively populating the periodic table of elements in terms of filling the gaps, once the basic structure has been hypothesized that the properties of chemicals and their compounds, as well as the properties of the last, are periodic functions of the atomic weights of elements (Brito et al. 2005). However, the chemical approach of atomic weight to the table was still leaving a number of problems and "[t]here are omissions in this 1911 table, some of them due to elements not yet discovered and others because a series of elements simply did not fit" (Cropper 2001, p. 318–20). Again, a "gap feeling" leads to a "gap filling" through imaginative work, when Harry Moseley engaged in the puzzle of finding a better way to populate the table at Rutherford's laboratory in Manchester. He finally came out with the equation to determine the atomic numbers of elements, opening the way to a cycle of hypothesizing and discovering new elements that was largely applied in nuclear physics: "Moseley's unambiguous evaluation of atomic numbers also showed gaps where there was a number, but no known element that matched it" (Cropper 2001, p. 321). Such gaps operated as driving force and guidance for physicists to run after the discovery of a number of new and still unknown elements (Cropper 2001). As in the case of Hume's blue, a combination of imaginative and non-imaginative work, feeding into each other, enables an alternate movement of opening and filling gaps (Pelaprat and Cole 2011) that leads to the elaboration of new knowledge. Neither inductive/deductive forms of inference or imagination alone could have solved the problem of the periodic table, as a combination of the two was necessary.

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Chapter 3
Imagination in Science

Natural sciences have soon become very aware of the role of imaginative activity in both discoveries and explanations. For instance, Jacobus Henricus van't Hoff gave an inaugural lecture in Amsterdam, on October 11 of 1878, entitled *Imagination in Science*, as he was appointed full Professor of Chemistry, Mineralogy, and Geology, at the age of 26 (van't Hoff 1967). In the lecture, he aimed to discuss, "[t]he role of the imagination in investigating the connection between cause and effect" (van't Hoff 1967, p. 8). Starting from an idea of imagination as the capability to observe, visualize, and manipulate mental images, van't Hoff went through the history of classical science providing examples of how famous scientists, from Kepler to Galilei and Schopenhauer to Watt, were engaged in imaginative work. He claimed that:

> in the mechanism of investigating a causal connection imagination is necessary in five operations.
>
> 1. In the choice of the moment or the object of observation.
> 2. In the discretionary alteration of the observed.
> 3. In the finding of aids, which facilitate observation, and frequently even are a prerequisite to make it possible.
> 4. In the observation of a correspondence or a dissimilarity.
> 5. In the setting up of a hypothesis.
>
> This mechanism by itself is sterile. The individual who possesses all these qualifications required by this mechanism will nevertheless remain without any significance if he lacks the irresistible drive to make use of these abilities, and this compelling drive which manifests itself first as enthusiasm and subsequently as perseverance is frequently the pursuit of an idea which exists only in the mind of the investigator and consequently represents the result of imagination. (van't Hoff 1967, p. 11).

van't Hoff's statement adds another element to our exploration: imagining is part of an activity of investigation that plays a role in different moments of the scientific process, yet it is characterized by a tension toward something, as in Leonardo's example, rather than just a "gap feeling." Thus, imagining is not only useful in identifying causal relations, but also producing new research objectives: in other words, it is teleogenetic.

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So far, we have navigated through examples of imaginative work in different ages and domains of science. Imagining is a synthetic faculty, organizing, mediating, integrating, and rotating the elements of senses, but at the same time, according to Kant, it has also a transcendental function that makes empirical intuitions possible (Lapoujade 1988; Sepper 2013). In this vein, imagination "marks the limits of possible knowledge. Human knowing reaches as far as imagination goes […] imagination eminently plays a mediation function, as it presents a double face: one looks to sensibility, through which it works; the other looks to understanding, accepting its rules in the epistemic processes" (Lapoujade 1988, p. 80-81, my translation). In van't Hoff's words, imagination is at play in the initial choice of the object, the moment, and the meditational tool of observation, so it is setting the stage. Then, it is work in the synthetic elaboration of empirical data—observing differences and similarities and formulating hypotheses—that leads to a new cycle. In Kant's term, imagination plays a complementary role in formulating judgments, both in subsuming an intuition into a category and in applying a category to an intuition (Lapoujade 1988).

However, van't Hoff finally notes that understanding imagination only in terms of procedure for producing judgments would result "sterile." One needs also an element of perseverance, affect, and even passion toward one's own object of imaginative work.

> Such creations of the imagination, they may be correct or erroneous, have brought about miracles: the firm belief in the influence of celestial bodies on the fate of mankind and also that in the philosopher's stone have served astronomy and chemistry inestimably. (van't Hoff 1967, p. 11).

The most famous case was probably the interest of Isaac Newton for alchemy that was perfectly consistent with his goal of understanding the eternal plan of God through the study of mathematics physics as well as biblical prophecies (Cropper 2001). Newton possessed 138 books of alchemy in his library at the time of his death. He combined the hermetic poetry of alchemy with the rigorous empirical method. "He accumulated more than a million words of manuscript material" (Cropper 2001, p. 27). One can find more specimens of this "compelling drive" even the history of twentieth century: "When Enrico Fermi and his colleagues at Los Alamos were laying the ground for civilian nuclear power, they saw themselves as the new alchemists, using nuclear fission to transmute matter" (Wilson 2002, p. 233).

Science Driven by the Power of Imaginative Activity

The imaginative activity in all branches of science is purposefully directed toward existential, political, theological, and economic future goals. A large deal of the Western colonialist project is the result of a combination between (a) a non-imaginative search for social, economic, and political dominance and (b) an imaginative creation of universal scientific laws of progress, of course in favor of the colonizing civilizations: a veritable imaginary of domination (Nederveeen and Parekh 1995).

The non-imaginative colonial domination was nurturing the will of power into an imaginary of domination that in return was supporting the continuation of the colonial exploitation. This is why at a certain point in contemporary history, the obsession for the origins becomes an arena in which imaginative and non-imaginative scientific efforts are combined.

This long process of intellectual exploration could be clearly observed in Germany across the nineteenth and twentieth centuries. In that specific cultural *milieu*, science was highly valued and at the same time an idealistic view of whole was preserved in *Naturphilosophie* (Harrington 1996). One usually considers Germany as the scenario arena in which the modern dialectic between "*Erklären* (causal understanding) and those sciences—primarily the human and social sciences—that must derive their chief insights through the methods of *Verstehen* (hermeneutic interpretation)" (Harrington 1996, p. 27): the former inductively looking at mechanical analysis of phenomena, and the latter abductively grasping *wholes* or *Gestalten*. The former empirically and physiologically based—like in the work of Weber (1795–1878) and Fechner (1801–1887), who used quantitative methods focusing "on perception of incremental, elemental sensations" (Harrington, 1996, p. 15)—and the latter "dominated by a process of empathic re-experiencing (*nacherleben*), like in Goethe or Dewey" (Harrington 1996, p. 27). Anne Harrington (1996) explains this dialectic with the German search for a *unity*, and at the same time for a *uniqueness*. What I want to stress here is that in both horns of the dilemma, an important role is played by the imaginative dimension:

> In the sciences, this imperative to find an uneasy balancing act between individualism and unity would find echoes in even so apparently esoteric a matter as Rudolf Virchow's discussion of cell theory. Twentieth-century holists would remember Virchow's work as a landmark moment in the atomization of life; but in fact matters were not so straightforward. In his classic 1855 paper on cellular pathology, Virchow did defend the need to think about life and pathology from the perspective of its cellular processes. However, in so doing, he emphasized ways in which the reader must imagine the individual cell itself as a type of micro-whole (Harrington 1996, p. 12)

It is not a coincidence that life sciences became a privileged arena for the play of the dialectic between what I would call *empirical* and *empathic* epistemologies. Organic systems are indeed characterized by (a) the problem of genesis (where do life comes from); (b) the problem of wholes (what is the significance of the constituent parts); and (c) the problem of boundaries (what are the limits between life and nonlife) (Marsico and Varzi 2016). One can find these three problems at work in von Uexküll (2013) theory, and observe how the empirical work of observation of animal life is connected with the empathic world of theorization about human and social life. The combination between the three problematic fields led in Germany to the development of complex theories about the origins, purity, and unity of human collectives, in which imaginative and non-imaginative work conspired with the sociopolitical orientations.

A good example of this drive can be found landing in the context of Brazilian history of natural sciences (Sá and da Silva 2016). It is common knowledge that during the 1930s, profiting of the good relationships between German Nazi's regime

and Vargas' regime, several scientific expeditions were organized by German natural historians, ethnographers, geographers, anthropologists, geologists, zoologists, etc. to visit especially the Amazonas. From 1933, the cultural section of the German Foreign Office—responsible for the international scientific interchange and cooperation, international scientific meetings and publications, and visit of German scholars abroad—started to overlap with the Foreign Organization of the Nazi Party and Goebbel's Ministry of Propaganda (Sá and da Silva 2016). In this way, German science started to be governed so as to serve the interests of the Reich's policies rather than just pursuing scientific goals.

Among the expeditions, there is one which is especially memorable for its impact both on mass media and on the bilateral relationships between Brazil and Germany. The expedition was led by the zoologist and geographer Otto Schulz-Kampfhenkel, who between 1935 and 1938, at the age of 25, explored the Amazon region bathed by the Jari River (Fig. 3.1) (Sá and da Silva 2016).

This kind of expeditions were characterized by a mix of scientific, political, economic, and propaganda interests. The Brazilian academic world had traditionally a lot of scientific relationships with German culture. Many researchers were educated in Germany and several German immigrants were established also as academics in the developing Brazilian universities and research centers (Sá and da Silva 2016). However, at that point, Brazil started to exert a strong attraction to German scientists, especially in the region of Amazon. This attraction met the interests of the Third Reich's regime and went far beyond the exploration and exploitation of virgin natural resources of Latin America's inner land. This is where imagination sets the scene.

Schulz-Kampfhenkel was a young and ambitious scientist, who had joined the Nazi Party and the SS; he also had built for himself the "scientific identity at the interface between science and amateurishness, representing himself as the archetypal explorer of remote regions on Earth" (Sá and da Silva 2016, p. 246). Schulz-Kampfhenkel's expedition was financed by several German ministries and rich private collectors and media. He was very good in public relations and was able to sell in advance the forthcoming reports of the journey to the Tropics. The whole expedition was driven by a complex of imagery related both to the exotic and to the eugenic ideologies of the Third Reich. For Germans, both Nazis and refugees escaping from Nazism, Brazil has represented a sort of mythical land of opportunities (Wallisch and Novus 2015). Especially the inner areas of *sertão* (backcountry) and Amazon were imagined as primary and virgin territories, a horn of plenty where Western civilized explorer can take possession of a "tropical empire" (Wallisch and Novus 2015, p. 225). After returning to Germany, Schulz-Kampfhenkel started to produce and organize exhibitions, a documentary film, and books about his journey with quite an audience and economic success.

> The German expeditions testified to how Brazilian people and nature remained attractive to German scientists, and how the scientists and adventurers acted to shape the public imagination in order to gain support to undertake their trips to the country and legitimize their professional careers. They also show the persistence of a stereotypical vision of the South American country as an uncharted land, full of possibilities, with lush natural resources counterbalanced by what they saw as unsatisfactory political and economic development. (Sá and da Silva 2016, p. 248-49)

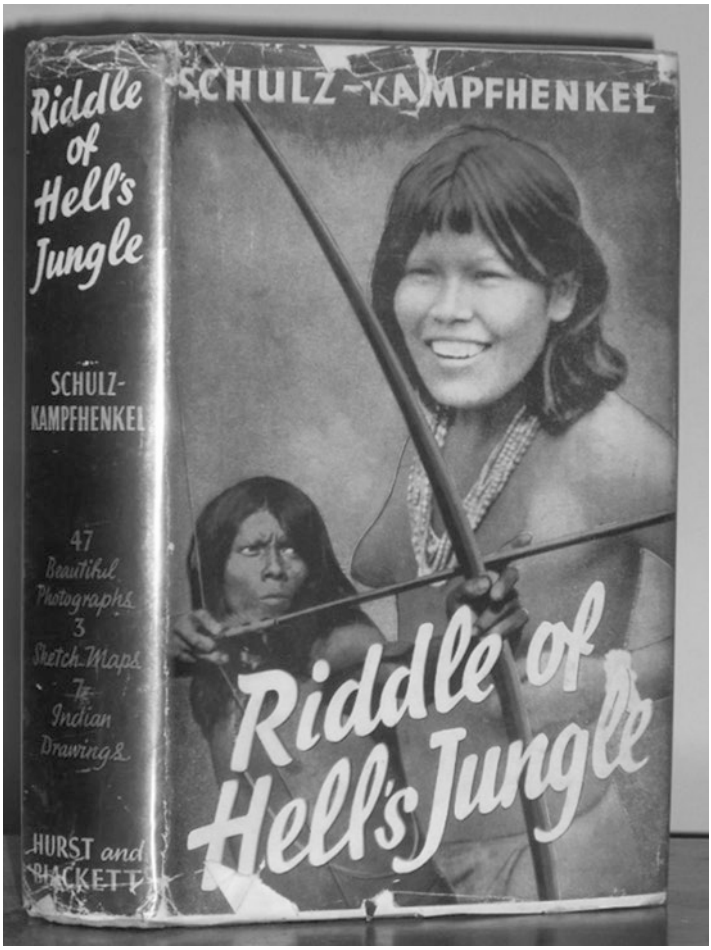

Fig. 3.1 Original cover of the English edition of "Rätsel in der Urwaldhölle" (Schulz-Kampfhenkel 1940)

At the same time, population and fauna of the Amazon represent a mythical imagery of an Eden-like condition, an untouched piece of Earth where Nazi's obsession with origins and purity could turn to look for mythological ancestors. Schulz-Kampfhenkel's expedition perfectly embodied all these elements: the machos figure of the German explorer; the exotic imagery of the harsh Mother Nature in the Hell's Jungle[1]; the

[1] The expedition was characterized by several accidents, loss of equipment and detours due to the poor experience of the crew, and even the death of Joseph Greiner, a member of the German team who caught the malaria and died. "To this day, a wooden cross topped with a swastika marks the place where he was buried, its presence giving rise to all sorts of stories about the Germans' journey to the region" (Sá and da Silva 2016, p. 241).

stereotypical pictures of *indios* living their primitive but joyful lives without (apparent) pain; and the spoils brought back to Germany for the curiosity of the public.

We have shown so far how imagining is at play in different fields and in different aspects of science. It links and mediates between empirical and conceptual, between present and absent, between goals and desires, and between what is known and what is yet to know. In other words, imagining seems to dwell both at the center and at the borders of the phenomenal field, striving to overcome those very borders and constantly displacing the center. Yet we are still lacking a definition of imaginative processes, so my next task will be that of briefly reviewing the history of the concept, before coming back to its role in science.

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Chapter 4
A Brief History of an Unachieved Definition

One can say that human and social sciences have been very imaginative in providing a number of different definitions of imagination since then. Stevenson (2003) has tried to group and discuss them, identifying 12 main conceptions since Aquinas to the present days:

> (1) The ability to think of something not presently perceived, but spatiotemporally real. (2) The ability to think of whatever one acknowledges as possible in the spatiotemporal world. (3) The liability to think of something that the subject believes to be real, but which is not. (4) The ability to think of things that one conceives of as fictional. (5) The ability to entertain mental images. (6) The ability to think of anything at all. (7) The nonrational operations of the mind, that is, those explicable in terms of causes rather than reasons. (8) The ability to form perceptual beliefs about public objects in space and time. (9) The ability to sensuously appreciate works of art or objects of natural beauty without classifying them under concepts or thinking of them as useful. (10) The ability to create works of art that encourage such sensuous appreciation. (11) The ability to appreciate things that are expressive or revelatory of the meaning of human life. (12) The ability to create works of art that express something deep about the meaning of life (Stevenson 2003, p. 238).

Sepper (2013) explores instead the historical development of the concept of imagination from Plato (fourth century BCE) to Castoriadis (in the late 1980s). It is an impressive historical and philosophical *tour de force* that still leaves the reader with a lot of open questions. He explains that for a long time there have been "two common, inveterate, even insidious misunderstandings of imagination. The more recent one identifies it with creativity" (Sepper 2013, p. 17). This is the current view also of those who strive for improving the "creativity" and "innovation" capability of researchers to provide "groundbreaking" discoveries. The second traditional conception understands "the prototypical model of the imaginative act has been visualizing an absent object" (ibid.). Both ideas are reductive and thus misleading, even though they can capture some features of imaginative activity. However, when it comes to provide his own definition, Sepper (2013) must face similar problems of extensionality and intensionality of definition, as those described by Stevenson (2003):

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> Imagination is a (psychologically) evocative, anticipatory, abstractional-concretional activity that follows upon actual perception. It allows the imaginer to (1) dynamically (re) position herself and incipiently explore, place, vary, connect, and re–present appearances originating within a field of concern, (2) attend to and mark the field's potentials, and (3) exploit those potentials by projecting them to other fields (possibly new) in abstracted/concreted appearances. (Sepper 2013, p. 488)

Lapoujade (1988, 2018) tries instead to move a step beyond the reconnaissance, systematization, and reformulation of historical definitions. She attempts to build a philosophical theory of imagination, by identifying it as a function of the human mind and by describing its structure. According to Lapoujade (1988), imagination is a future-oriented and intentional psychical function, with a temporal development. It plays the twofold role of mediating—between sensibility and intellect, and between will and reason—and of setting the limits of human experience while at the same time showing the possibility of transgressing them.

All the abovementioned definitions share the common goal of overcoming the traditional understanding of imagination as a mere capability of organizing sensations in visual complexes or creating a simulation of the enactment of thought (Fig. 4.1). This idea is rooted in Aristotle's theory of mind that (a) whatever is in intellect was originally in sense, and (b) there is no thinking without images. Imagination (*phantasia*) is a motion from the sense impression to the creation of mental images. One cannot think of something without first creating an attenuated, blurred, and imperfect image of the percept, a diminished sensory experience, which is defined and memorized through repetition (Schofield 1992). Imagination also goes in the opposite direction: from the inner mental work to the external reality, a preparation to action in which the organism experiences an appetite for something: a *phantasia aistetiké*, a *simulation* that the organism has before being ready for action.

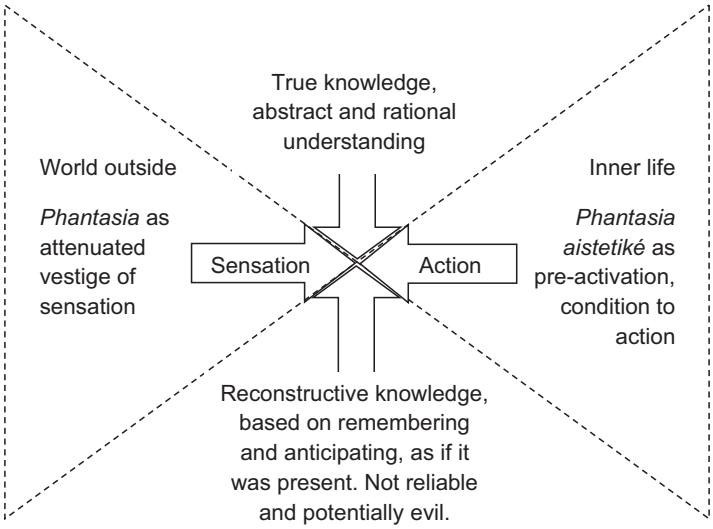

Fig. 4.1 Imagination as "in between" (adapted from Tateo 2016, p. 155)

The second heavy mortgage on imagination was established by Augustine (Cocking 2005; Lapoujade 1988). According to him, there are three different degrees of seeing: "bodily seeing, which is sensation together with consciousness of sensation, the mental representation or 'spiritual seeing'; 'spiritual seeing' on its own, without sensation, which includes what we now call imagining and dreaming; and 'intellectual seeing' or understanding" (Cocking 2005, p. 43). Imagination is placed at a lower level than understanding, while abstract knowledge is repeatedly distinguished from mental images that have no guarantee to be true.

The traditional conceptions of imagination develop along these two axes: imagination is an in-between condition, whose nature is hard to handle and even suspect. A direction that goes from senses to intellect locates imagination as the capability of creating visual representation of sense impressions, namely re-presentations of presentations. But it is also the capability of (pre)sentations of enacting and desires. In both cases, the work of imagination detaches the objects from its mental correlates. As centuries later Sartre will put it, imagination poses its own object (Lapoujade 1988). On the second axis, imagination is located in that phantasmatic realm, that Middle-earth, whose inhabitants are the dream, the vision, and the precognition. I personally find here a sort of ambiguous understanding that characterizes the classical conceptions of imagination. Because of its capability of producing images in the absence of the represented object, it is at the same time too empirical and not enough empirical. If one takes rationality as the process that matches ideas and things, inductively or deductively according to the direction one chooses, then imagination is in a certain sense undecidable, as it is neither idea nor thing. It is a particular realm in between in which intentionality constitutes a goal-oriented representation of ideas that are no longer or not-yet things.

For its generative potential, imagination was partly rehabilitated during the Renaissance, as part of the celebration of human creativity (Tateo 2016). Humanists like Marsilio Ficino (1433–1499) outlined "the notion of imagination as the artist's creative faculty" (Cocking 2005, p. 105). The flourishing of inventions and technical and artistic products was seen as a mark of human practical creative skills. Ficino established the relationship between creativity and imagination: "creativity in general is *ingenium*, just as poetic inventiveness was *ingegno*, and more specifically *alto ingegno*, for Dante" (Cocking 2005, p. 105). Ficino kept *fantasia* in between sensation and rationality, and still discriminated between passive and active features: imagination synthesizes in absentia of the real object, fantasy recognizes and combines different elements into a unitary presentation, while intelligence finally understands:

> Renaissance philosophers saw the imagination as a mediator between the body and the soul, the intellect and the senses, the appetites and the will, between the animal and natural functions of the body, motion and rest, past and future, between memories, dreams and prophecies, between nature and culture. (Giglioni 2013, p. 176)

Gianfrancesco Pico della Mirandola (1469–1533), in his *De imaginatione* (1501), first recognizes that the imagination can be culturally conditioned (Fig. 4.2).

Fig. 4.2 Portrait of Gianfrancesco II Pico della Mirandola, by anonymous painter of Italian School—Westminster College.edu, Lombardia Beni Culturali, public domain, https://commons.wikimedia.org/w/index.php?curid=6676044

As his contemporary Leonardo da Vinci, Pico della Mirandola attributes a great relevance to imagination. Nothing can be desired or understood if it is not somehow known beforehand. We cannot appreciate or want what we actually do not know. In this sense, imagination, with its capability of presenting to the intellect what is not present in matter, is the necessary cognitive activity for the formation of will and moral. However, as Pico is concerned with moral philosophy, rather than natural philosophy, he is also critical with respect to the cultural influences on imagination. Indeed, he says that the pagan culture is distorting imagination while only in Christianity imagination can give us a direct and nonintellectual access to the idea of God.

Giambattista Vico and Imagination as Force of Civilization

The next fundamental period in the history of imagination is what one could call the Vico-Descartes controversy that I have discussed at length (Tateo 2015, 2016; 2017). Both Descartes and Vico discuss imagination as a very important element in the generation of new ideas. However, Giambattista Vico (1668–1744) defends the epistemological status of imagination in generating universals in the different civilizations. For Vico, imagination is a proper and primal form of knowledge based on the three fundamental functions of the mind:

(a) *Fantasy*: the capability to imitate and change
(b) *Ingeniousness*: the capability to create correspondence between things
(c) *Memory*: the capability to remember

> All three appertain to the primary operation of the mind whose regulating art is topics, just as the regulating art of the second operation of the mind is criticism; and as the latter is the art of judging, so the former is the art of inventing. And since naturally the discovery or invention of things comes before criticism of them, it was fitting that the infancy of the world should concern itself with the first operation of the human mind, for the world then had need of all inventions for the necessities and utilities of life, all of which had been provided before the philosophers appeared. (Vico 1744/1948, p. 236)

According to Vico, imagination is an ancient form of knowledge that follows a specific logic called *poetic logic*[1] (Tateo 2016). Since primitive civilizations, such a logic, starting from an undefined feeling (e.g., primitive fear of meteorological phenomena like thunder), creates a familiar explanation rooted in the sensory (e.g., Jupiter as an omnipotent anthropomorphic being) that becomes a universal and iconic concept (e.g., divinity), acting as a self-regulatory tool for collective human action. Vico claims that through this specific mode of thought, historically situated and with its own rules, originated all forms of human civilizations. Imagination is not opposed to rationality, but represents the ground on which rationality itself could develop along the history of civilization. Hence there is the controversy with Descartes about the primacy of mathematical rationality. While the latter is useful in understanding the realm of natural sciences, it can be noxious when it comes to the understanding of human nature, which follows different laws (Tateo 2016). In this case, we must rely on the fact that we share the capability of making our own social world and so we can understand the others only by applying our "common sense," that is, the common understanding of human beings. Such an understanding can be achieved through the human capability to access the radical alterity of other civilizations through imagination (Tateo 2016). Literally, we can come to know what people in other times or other places of the world can think only if we start by imagining how it could be to live in their way. With an incredible anticipation, Vico claimed that the forms of human civilization are historically situated and cannot be understood in terms of comparing absolute traits, rather assuming the perspective of the other (Tateo 2017, 2018).

Vico's idea of imagination will be revived by Romanticism. Yet, while Vico considered human phenomena as a specific domain of knowledge, acknowledging a different epistemological status to natural sciences, the Romantic Natural Philosophy tried to develop a general theory of knowledge starting from the primacy, among the forms of knowledge, of the intuitive perception, of the direct experience of the world: as the knower "perceives the world only in himself, and himself only in the world" (Goethe 1820/1998, p. 38). Goethe revalues the epistemic value of imagination, trying to synthesize rationality and phantasy. Romanticism, instead, by claiming imagination as "all-encompassing," reproduced the opposition with rationality, whose effects we can still see today (Sepper 2013).

[1] Vico draws upon the epistemology of the word "poetic," coming from ancient Greek verb *poiein*, whose main meaning is "making." So, for Vico, poetry was a form of "making," of creating the human reality.

Looking for a Definition

We can now try to close the circle, and go back to the different definitions of imagination that we have encountered in the beginning of the chapter. One can see how the historical development of the concept of imagination has been characterized by some constants and, on the contrary, by some expansions of its meaning.

On the basis of the analysis of the previous theories, I think that two relevant features must be considered relevant: the intentional and the temporal nature of imaginative work. Imagining is an intentional activity oriented toward the future, even when we imagine the past (Fig. 4.3) (Tanggaard and Tateo 2018). What we usually consider the past-as-a-given is experienced in the forms of discursively structured forms of representations, whose verbalization is goal oriented (the past serves the future). Psychology usually collects these representations by different methodologies and considers them valid "data" only if produced at the present moment (through interviews, tests, etc.). Hence, there is the perceived asymmetry between past and future in imaginative work. Indeed, we consider the future as the realm of imagination, with its open-ended and uncertain possibilities, while the past is just a matter of more or less controversial reconstructive remembering of certain events.

If one considers instead the complementarity between imaginative and non-imaginative modes of thought in psychic activity, one can realize the relevance of the modal dimensions of psychological experience (De Luca Picione and Freda 2016). Thinking about the future implies the production of modal alternatives that recall each other. If I think about how things could be in the future, on the basis of goal-oriented intentionality, I also imagine what they could be or should *be not*.

The reconstructive activity of the past events, however, is no less based on such imaginative activity that evokes modal alternatives. The Italian writer Italo Calvino represents it in a wonderful passage of a novel, in which in an enchanted night tavern, the stories of many occasional travelers come out to be inextricably interwoven. One of the characters of the novel confesses:

> Because in this way all I did was to accumulate past after past behind me, multiplying the pasts, and if one life was too dense and ramified and embroiled for me to bear it always with me, imagine so many lives, each with its own past and the pasts of the other lives that continue to become entangled one with the other (Calvino 1981, p. 106).

The discursive structuring of a past event is at the same time evoking complementary alternatives: what happened, which is inevitably considered what *had to* happen, immediately evokes what could have or *should have not* happened. One can find this process at work both at the individual level (I studied X despite my parents wanted me to become Y, so now I am a psychologist and not a lawyer) and at the collective level (our nation X is fated to become great because our origins are Y and all the other nations are not-Y, like in the case of the nineteenth- and twentieth-century German obsession of origins; see Chap. 3).

Another important acquisition, related to the previous one, is that imagination is not limited to a reorganization of the previous experiences: the productive side of it

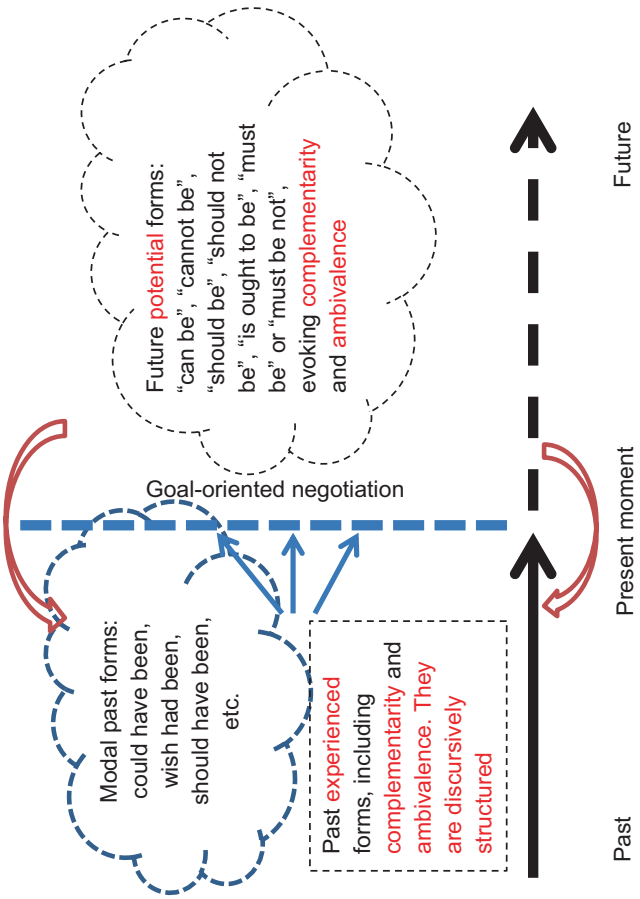

Fig. 4.3 The dance of becoming between real and unreal in irreversible time (Tangaard & Tateo 2018)

has progressively become more important than the reproductive one. According to Vygotsky (2004), imagination is the cradle of any human product. Nothing can exist in reality that before was not in the imagination. It is the "human creative activity that makes the human being a creature oriented toward the future, creating the future and thus altering his own present" (Vygotsky 2004, p. 9). The productive feature of imaginative activity becomes of course extremely important in scientific work (see for instance the case of Leonardo in Chap. 2). In the case of thought experiments, for instance, one can see how reconstructive elaboration of previous experiences or empirical knowledge is only partially useful in the production of new ideas.

> Scientific thought experiments are typically factive; they are attempts to elicit physical intuitions about what would happen under certain conditions. Such thought experiments are puzzling because they seem to describe cases where we learn something new about the physical world, even though we have no new empirical information about the world (Gendler 2000, p. 150)

In the next chapter, I will discuss in detail the example of thought experiments in science as a specimen of my theory about the relationship between imaginative processes and knowledge building. For the moment, it is suffice to notice that the scheme in Fig. 4.3 also applies to scientific work. Indeed, imaginative work in thought experiments allows not only to "*learn something new*," but also to reorganize the discursive form of previous knowledge (if imagining the case X as true, then also the previous knowledge Y could become Z).

Orthogonal to the past-future relation, I want to stress the function of relating abstract and concrete. The thought experiment is not only producing new ideas from a mix of previous and new imaginative work, but also creating an imaginary representation, an epistemic image (Lüthy and Smets 2009), of sometimes abstract concepts. At the same time, the lure of the concrete image can orient the creation of abstract concepts (Fig. 4.4).

A simple graphic representation of six equal circles around a seventh central one becomes the attractor of a number of theories in different epochs. Figure 4.4 shows the power o this image (from left to right): the perfection of the number 6 (Bradwardine 1530); the numerological logic of the six days of creation (Bongo 1585); seven worlds touching (Bruno 1584), and; atoms aggregate to form larger globules (Bruno 1591). The image is based on the idea of the circle as a symbol of perception (an abstract concept). Moreover, the seven circles form a whole in which the centers of the six peripheral circles coincide with the extremities of the three diameters crossing the center of the central circle. Besides, the six sides formed by the new figure can be inscribed into a new circle. The numerological meanings of the figures constituted the speculative basis for all the different uses of the similar images in Fig. 4.4. This mutual feeding of abstract and concrete is so powerful that one can still find it in contemporary representations of physics (Barth and Brune 1998) (Fig. 4.5).

The imaginative power of relating concrete and abstract—that we find already in the conceptions of Descartes, Vico, and Kant—will result extremely important also for the discussion of the epistemic and pedagogical role of imagining in science.

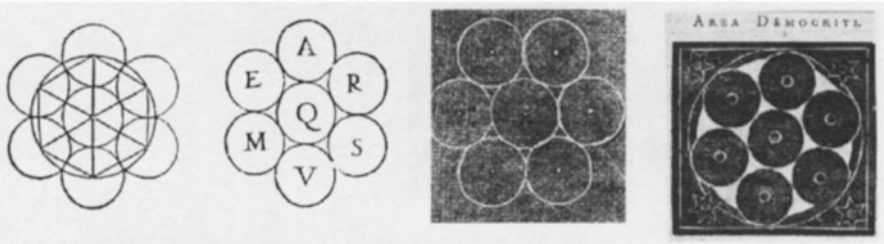

Fig. 4.4 Different images of six circles of equal diameter grouped around a seventh (Lüthy and Smets 2009, p. 407)

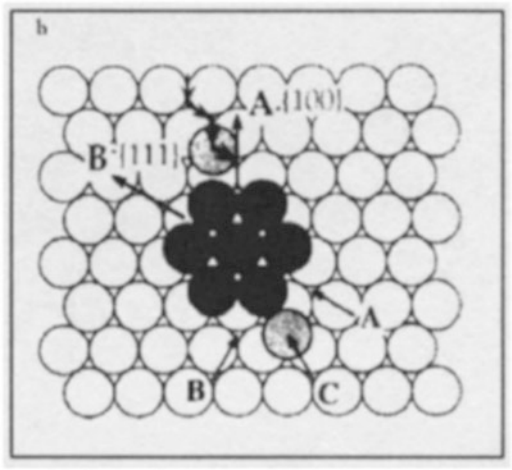

Fig. 4.5 Seven circles modelling "dendritic growth" of silver atoms (Barth & Brune, 1998, p. 256)

Imagining connects abstract and concrete in both directions (Tateo 2015, 2016). So, one can make concrete objects from abstract concepts (e.g., the personification of Justice or knowledge as Athena) or we can make abstract concepts from concrete objects (e.g., Rutherford's atomic model out of planet system image, or the cross as a symbol of Christianity). Imaginative work links both affectively and conceptually the abstract and the concrete, establishing a metonymical relationship: we produce judgments and beliefs that work for both (i.e., the abstract and the concrete). For instance, humans can kill or die for an idea or a concept as if it was real or they can let an object dominate their lives.

From the discussion of imagination along the history of ideas, we have discussed how it works to produce a mutual feeding of past into future and of concrete and abstract. In this sense, imaginative processes are not constructing different modes of existence (real versus imaginary), rather constituting mode of existence which is enriched by complementary modalities of thought (imaginative *and* non-imaginative). In the next section, we will see how the features of imaginative work are fundamental and complementary to knowledge as well as those of the understanding. But let me begin with a very simple thought experiment.

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Chapter 5
Imaginative Processes and Generalization

I guess that the most part of you is reading this book sitting or standing somewhere (maybe on a chair, on the floor, in the metro train, on a bench in the park, or, hopefully, on the sand of a beach). Now, I would like to invite you to focus on the exact position of your body while reading. Try to figure out what is the position of your limbs, and how the weight and the force are distributed. Try to visualize the exact position of your bones, to catch the feeling of tension and relaxation. Try to become aware of the energy required in the event of changing position. Try to figure out the position, the shape, and the size of your organs. Where is the heart? Where is the liver? Where is your gallbladder? Can you identify its contours?

You can close your eyes for a while, if you need, or you can even touch yourself. Then, take some time to reflect upon the thoughts, images, and feelings arousing. How do you represent your body? How do you feel or visualize your limbs, and the inner parts? How do you *know* what is your exact position while sitting?

This little thought experiment is meant to have access to our own bodily feeling. In theory, our body is the most personal thing we own, especially the inner part of our body, which is responsible not only for the position we assume while sitting and reading, but also for our own survival (our heart is really important). However, when we try to access the apparently most intimate part of ourselves, we realize that we have no direct access to it. In a certain sense, the only way to achieve a certain knowledge is by mediation. What does this mediation consist of? We can use the previous knowledge acquired through education and media, using the images and anatomical representations of the body we have developed and learned to appreciate along history (Fig. 5.1). We can use the knowledge of other people, who told us how the body is done and assuming that all the human bodies are similar. Finally, we must use some form of imaginative work, when it comes to accessing our own body *here and now*.

So far, we have learned from Hume that empirical knowledge is complemented by imagination. We have learned from Vico that knowledge of the alterity is complemented by imagination. From our simple thought experiment, we have finally

L. Tateo, *A Theory of Imagining, Knowing, and Understanding*, SpringerBriefs in Psychology, https://doi.org/10.1007/978-3-030-38025-0_5

Fig. 5.1 Rembrandt van Rijn, The Anatomy Lesson of Dr. Nicolaes Tulp (ca. 1632). Download from https://commons.wikimedia.org/wiki/File:Rembrandt_-_The_Anatomy_Lesson_of_Dr_Nicolaes_Tulp.jpg

learned by ourselves that even the most personal and intimate knowledge is complemented by imagination.

It is legitimate to consider that maybe imagining plays a constant complementary part in accessing the world and generating knowledge and understanding about it. Traditionally, some limited epistemic role would be granted to the forms of intuitive knowledge and insight (Sepper 2013). Yet I will try to explore whether this role can also be related to processes of abductive inference, abstraction, and generalization (Tateo 2015).

Knowing Through Imagining

In my limited knowledge of the epistemology of psychology, I can observe that, as a general matter, there are some things we are more certain about and other things we are less certain about. I can represent this phenomenological field as a round bubble with myself at the center, in the same sense of the perceptive/effective bubble of any living system (von Uexküll 2013). If I would have the same degree of certainty about all the events in myself and in the world surrounding me, the bubble

would have a perfectly spherical shape. In any direction I look, I will have the same certainty about my beliefs and expectations.

However, in real life, the situation is definitely different: simply, we are surer about some things and less sure about other things. For instance, I can be sure about my (in)fidelity to a certain degree, but I would have some problems in admitting that I have the same degree of certainty about the (in)fidelity of my partner. The bubble expands in all directions; indeed, my degree of certainty is also inscribed in irreversible time (see Fig. 4.3) to the extent that I can probably be surer about things in my past and less sure about what is going to happen in the future.

This observation is independent of the means we use to produce any inference about the world. Simply, there are things in our universe of discourse about which we can make some statements with a different degree of certainty (Tateo 2015), no matter whether we know something by experience, by habit, by guess, by induction, etc. Our universe has regions with different degrees of certainty, in all directions. Thus, I cannot represent it as a perfect spherical bubble, but it has rather an irregular shape, in which "me" as a knower occupies a decentered position (Fig. 5.2).

Every time in life we encounter a new phenomenon, the shape of our universe of discourse is subject to a change.

> The problem that a positive or negative encounter with an unfamiliar object poses for an individual is just the problem of inferring the consequential region to which that object belongs. (Shepard 1987, p. 1319)

Even if the space in Fig. 5.2 is bidimensional, we have to figure it as a tridimensional space, which extents in all directions, including the orthogonal relation between past and future and abstract and concrete. For instance, one can be surer about concrete feeling of pain/pleasure, and less sure about the abstract concepts of pain/pleasure. This is why we often use the concrete to give a body, a metaphorical presence, to the abstract. One can be surer about events happening in a certain temporal pattern (e.g., the sun will rise again tomorrow), and less sure about things in the future (e.g., I will win the lottery).

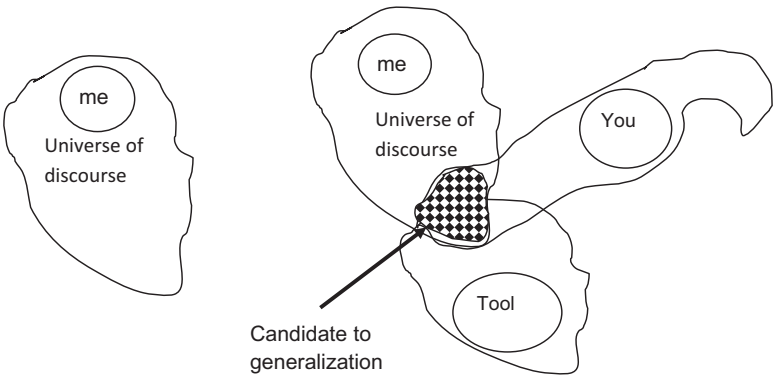

Fig. 5.2 Portions of universe and potential generalization

So, in order to become more certain about the regions of the universe of discourse we know worse, we do a very simple thing: we turn to the others or to tools. This is true in everyday life as well as in scientific practice.

> We then turn to others in order to strengthen our knowledge about the different parts of the portion of discourse universe, involving the socially organized forms of intersubjectivity and interobjectivity we use to call scientific inquiry. (Tateo 2015, p. 58)

The squared area in Fig. 5.2 represents the portion of the universe of discourse illuminated by the complementary force of first-person experience, imaginative activity, and cultural tools, which becomes a potential candidate to a generalizable knowledge. For instance, I can become surer about my future winning at the lottery by using my own experience as a gambler, by imagining a condition in which I can win, and by creating a special ritual, or a "scientific" method to win. All the three modalities will converge to give me some more or less solid estimate of my winning chances.

In the case of the thought experiment about sitting, even within the region of the universe of discourse which is closer to that "me" as knower, one realizes that any form of new knowledge cannot be attained without the mediation of the others or of the tools. However they can be cultural resources such as books, popular TV shows about the body, or lessons of anatomy at school. It is the role of the social interaction and the cultural resources as forms of vicarious experience already described by Vygotsky (2004). It is worth nothing that also in the case of vicarious experience that contributes to the expansion of our field of knowledge, the degree of certainty is different and it is largely determined by social factors, such as trust: I can believe more or less in the narrative of another person depending on the trust I have in the author.

Once the new portion of the universe of discourse is rendered denser by the cooperation between different agents and tools (see Fig. 5.2), this new region becomes a potential candidate to generalization (Tateo 2015).

> We generalize from one situation to another not because we cannot tell the difference between the two situations but because we judge that they are likely to belong to a set of situations having the same consequence. (Shepard 1987, p. 1322)

This is the very basic mechanism at stake, for instance, in the peer-reviewing of academic writing, after all. If one wants to improve the degree of certainty about a new portion of the universe of (scientific) discourse, represented by a manuscript or a study, one refers to an intersubjective process of integration of the portion as a candidate for a potential new scientific generalization of the knowledge produced. Sciences have of course formalized and made explicit and replicable the procedures through which the different subjects can share knowledge about specific portions of the universe of discourse. However, one of the relevant tools in the process of producing and sharing such a knowledge is imaginative work as complementary to the non-imaginative mode of thinking. As I will try to argue in the next section, several forms of imaginative activity, like thought experiments, metaphors, and utopias, play a relevant role in scientific discoveries. In order to support my claim, I will draw once more on examples from the biographies of famous scientists.

Thought Experiments and Utopias

We know how much thought experiments are important in science (Frappier et al. 2012; Gendler 2000). Relevant theories in philosophy, physics, chemistry, or politics would not have been possible without this tool for thinking. However, it is still hard for scientists to admit how much thought experiments rely upon the human imaginative activity (McAllister 2012). So far, I have discussed the complementarity between imaginative and non-imaginative modes of knowing in the constitution of the universe of discourse. Imagination, intersubjectivity, and interobjectivity work together to make familiar and denser new portions of the universe of discourse, so as to make them suitable candidates for generalization (Tateo 2015). In the following pages, I want to explore the different forms that the complementarity between imaginative and non-imaginative modes of thought assumes in scientific work. According to McAllister:

> Scientists use imagination in this sense when they conceive possible features of the world that they have not previously encountered empirically. Imagination is involved whenever scientists posit unobserved, unobservable, or nonactual states of affairs, such as in conjectures, counterfactual reasoning, predictions, models, and idealizations, as well as in thought experiments. (McAllister 2012, p. 11)

I think that if one pays closer attention to this type of phenomena, one will see that there are manifold manifestations of imaginative activity at stake. One can admit that thought experiments imply the complementarity between what one already knows—because one has inductively or deductively produced some knowledge—and what one does not know yet—because one has not yet encountered it empirically. This is exactly the situation described in the case Hume's blue (see Chap. 2): the non-yet-existing is driving the intellectual effort, and the presence of the absence becomes the place of generation.

So, are we dealing with an idea of imagination which is just a matter of *filling* the gap (Pelaprat and Cole 2011), or is instead also a matter of *feeling* the gap, of an imaginative work as a fundamental drive to knowledge? In the latter case, it is not only a work of imaginative building a part of a structure which is already defined by the borders of the other elements, like in a jigsaw. It is rather to produce an abduction[1] based on the production of a completely new element, an overcoming of the current state of affairs, not just a recombination of existing elements in a creative way.[2] According to Lapoujade (1988) it is exactly the work of imagination that of

[1] Abduction is a particular form of inference: "Since Peirce's theorization, scientific knowledge creation is understood as a triadic process of hypothesizing, modeling, and proving [.] Each step is characterized by a leading inferential structure, namely abduction to speculate on new hypotheses, deduction to draw the possible consequences and relationship and induction to prove the hypothesis. A theory can be said to be established when the knowledge achieves a character of generalization" (Tateo 2015, p. 48).

[2] Dazzani and Silva Filho (2019) systematically explore this idea in commentary 1, with reference to Peirce's theory of knowledge.

setting the limits of knowledge and at the same time denying those limits by offering a glimpse of their overcoming.

Let us take for instance Einstein's famous "elevator on a rope" thought experiment (Cropper 2001; Norton 2012). In its visionary complexity, it cannot be reduced to a mental handling of visual images or a recombination of previous experiences. Indeed, the initial almost "ordinary" condition—a man into a falling elevator—becomes more and more "visionary" as the different possible conditions—that are incidentally not empirically observable—are explored. The second step is to move the elevator upward in constant acceleration along an infinite rope raising in the sky: not bad for a clerk of a patent office. Then Einstein introduces an even more visionary element:

> Picture the elevator on a rope with a light ray traveling across the elevator from left to right [.] Because the light ray takes a finite time to travel from wall to wall, and the elevator is accelerated upward during that time, the outside observer sees the light ray traveling the slightly curved path shown. (Cropper 2001, p. 221)

Considering the fact that Einstein had direct knowledge of the elevators, but probably not even of those in high skyscrapers, which were uncommon in nineteenth-century Europe, one cannot ignore the relevance of imaginative work in this thought experiment. But there are even more examples.

In their famous biography of Stephen Hawking, White and Gribbin (2002) report some episodes of the life of this extraordinary person and one of the science's celebrities of the last two centuries. In the winter of 1963, at the age of 21, Hawking was diagnosed with the amyotrophic lateral sclerosis, or ALS, and was given no more than 24 months of life. However, he produced a remarkable piece of imaginative work, planning and working as if he could live up to the age of 87. But what I consider relevant, in the case of Hawking's biography, is that his style of thinking shows another example of complementarity between imaginative and non-imaginative activity. One of the episodes reported by White and Gribbin (2002) refers to the years of doctorate at Cambridge under the supervision of Dennis Sciama. Hawking, his supervisor, and some colleagues went to the King's College in London to attend a lecture of the mathematician Roger Penrose that would later become one of Hawking's most crucial fellows. This is how White and Gribbin (2002) narrate the episode:

> One night, on the way back to Cambridge, they were all seated together in a second-class compartment and had begun to discuss what had been said at the meeting that evening. Feeling disinclined to talk for a moment, Hawking peered through the window, watching the darkened fields stream past and the juxtaposition of his friends reflected in the glass. His colleagues were arguing over one of the finer mathematical points in Penrose's discussion. Suddenly, an idea struck him, and he looked away from the window. Turning to Sciama sitting across from him, he said, "I wonder what would happen if you applied Roger's singularity theory to the entire Universe." In the event it was that single idea that saved Hawking's Ph.D. and set him on the road to science superstardom. (White and Gribbin 2002, pp. 71-72)

In the case of Hawking, we are in the presence of a different work of imagination, though we can still consider it a thought experiment. So, I propose to define a

thought experiment as *a complementary work of imaginative and non-imaginative activity focusing on a specific problem that goes beyond the current limits of the universe of discourse*. But what about an activity that is not focusing on a specific problem, rather on a whole universe of discourse? In this case I would propose that this is the definition of *utopia* (Miščević 2012). For instance, one cannot consider Plato's *Republic* or More's *Utopia* as thought experiments of the same kind as Hume's blue. In the case of the utopia, the complementarity between imaginative and non-imaginative work is extended to cover a whole system in its political, social, ethical, and affective dimensions.

Thought experiments and utopias show us how imaginative work is not an incidental element that sometimes comes to interfere or to enrich the work of rationality. My claim is that imagining is a necessary though not sufficient condition for any new understanding (Fig. 5.3). Imaginative and non-imaginative works feed into each other.

In folk psychology, one would consider "crazy" those who cannot distinguish reality from fantasy. Yet, this conception is based on the old idea of imagination as alternative to reality. So far the examples I have discussed in the history of ideas suggest instead a complementarity between two modes of experiencing. Is this the case of Nazi expedition in Brazil, in which imaginative work drives the expedition, while the actual scientific experience of Schulz-Kampfhenkel feeds into further imaginative work? But is it also the case of Isaac Newton, in which alchemy and chemistry feed into each other in order to open new potential horizons of discovery? Imaginative work is indeed a fundamental part of psychic activity, and what we call fantasy is only one of the many phenomena based on imaginative processes as higher mental function (Tateo 2016, 2018).

The claim that imaginative and non-imaginative works form a complementary epistemic pair could guide a whole new set of theoretical and empirical research in

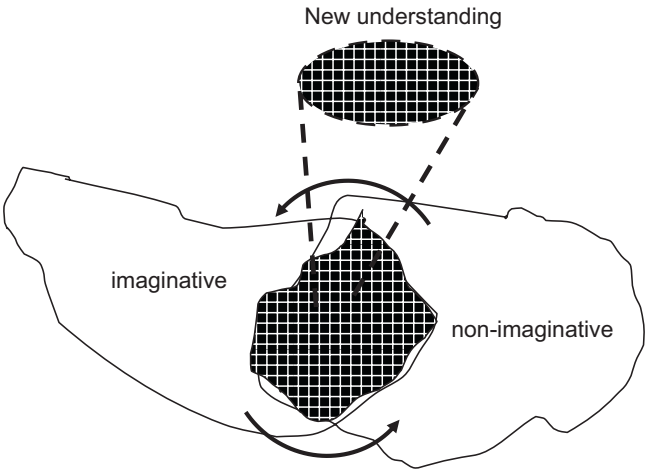

Fig. 5.3 Imaginative and non-imaginative activity

science epistemology. A number of new questions would arise. Is imaginative work at stake only in the "context of discovery," or also in the "context of justification"? Can we consider imagining as a sort of epistemic virtue? Is imagination at work only in the generation of hypotheses or also in their falsification? Is imaginative activity only constructive or also destructive (Tateo 2017)? What are the relationships between imagining, knowing, and understanding? If imagining is a higher mental function, what are the sociogenesis, ontogenesis, and phylogenesis of imaginative processes?

Expansive Imagination

An example of such potential for developing new research approaches has been already proposed for the field of cultural psychology (Branco and Valsiner 1997; Valsiner 2017). Branco and Valsiner (1997) have developed an epistemological approach over the years, focusing on the whole methodology cycle, in which the elements of the research must be feeding into each other and must be always considered as a whole (Fig. 5.4).

As human activity, science is initiated and carried on by human beings, in coordination with other human beings and mediated by social relationships and tools (see Fig. 5.2). I have reported several examples in the history of science in which the

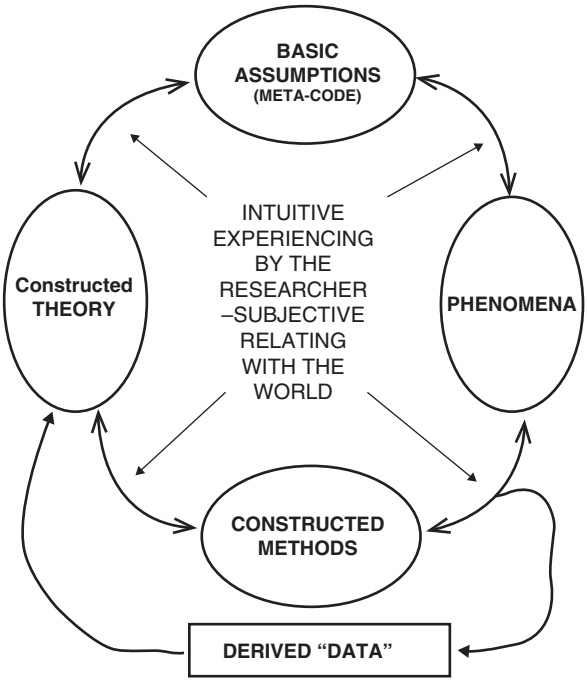

Fig. 5.4 The methodology cycle (based on Branco and Valsiner 1997)

personal intuition and the "drive" represent the ignition for a process of creating new knowledge and new understanding. Of course, there is a whole narrative about "insight" in science, like in the biographies of science celebrities like Einstein and Hawking, but it is quite clear that at least in some moment, the researcher's imaginative activity plays a relevant role.

> The educated intuition is at the very core of all science. The first question for a researcher is what research questions are worthwhile to ask in the first place? Intuition here comes first—yet it is educated, not naïve and not "pure." There are many layers of personal-cultural needs that turn an ordinary person into a scientist. Here the scientist and artist function similarly—the emergence of an idea is hidden somewhere in the internal infinity of our mind. (Valsiner 2017, p. 22)

According to Valsiner (2017), the activity of science is thus a socially guided and educated way of working out the personal curiosity and striving of the researcher, based on some meta-theoretical assumptions that can guide in the formulation of the theory but also in the interpretation of the data, as for instance in the cosmological views, like the book of Galileo, the God's plan of Newton, or the God's dices of Einstein, but also in the mechanical view of Descartes. On the other side of the cycle, meta-theoretical views will affect the definition of the phenomena to be observed.

The theoretical frame and the portion of the universe of discourse (that is, the phenomena) will affect the choice of the methods, yet at the same time, the methods will provide a specific picture of the phenomena. For instance, using some instruments will provide a different view of the phenomenon, but at the same time, specific phenomena, like an astronomic event, can become visible only with specific instruments. This relation is so tight that often researchers need to build an instrument for a single purpose of observing or producing a particular phenomenon. It should be clear so far, as Valsiner (2017) claims, that what we still call "data" are not a given fruit of nature that we simply harvest out there, but are as constructed and intertwined as all the other parts of the methodology cycle.

The assumptions can be very deeply related to the researcher's personal experience and biography, as for instance the religious beliefs, the existential reflections, or the ethnic and cultural background. Just consider for instance how relevant religious beliefs have been for both Galileo and Newton (Cropper 2001) or the Holocaust and the European scientific *diaspora* for the development of the science in the United States after the WWII. Following Vygotsky's theory (Vygotsky 2004) of imagination developing in the context of social interactions, which expand the field of experience through social mediation, one can deduce that science as collective activity is not only guided by a set of meta-theoretical assumptions and shared practices that affect the non-imaginative mode of thought. Imaginative mode of thought is involved in scientific work because it has the same origin, the internalized social interactions, as the non-imaginative one. It is the case of the seven circles of Fig. 4.4 in Chap. 5. Imaginative work can be a silent form of anticipation of an object (e.g., the atom), remaining latent for centuries before scientists develop the technology to observe it.

Branco and Valsiner's methodology cycle (Branco and Valsiner 1997) very nicely shows the complexity of science as human endeavor and at the same time provides a very rich potential framework for the study of the complementarity between imaginative and non-imaginative activity all around the cycle. In each part of the whole cycle, there is indeed an interaction between what we know and what we do not know *yet*. On the other hand, there is a constant relating between abstract and concrete, between concepts and objects, and between control and overcoming. These are all features that we have so far discussed in relation to the work of imagining. Thus, there are very good reasons to proceed with a systematic exploration of imaginative work in sciences.

If such an ambitious research program should be initiated, it is however required that scholars should be familiarized with the work of imaginative processes. If our experience of the world is always partly imaginative and partly non-imaginative, in other words, if we live in both constructed *and* imagined worlds (Tateo 2017, 2018), understanding the development and education of human imaginative activity becomes a fundamental task.

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Chapter 6
Conclusion: How Can We Build a Theory of Imagining

The purpose of this book is to elaborate a theory of imaginative processes as higher mental function in a cultural psychological perspective. In the previous chapters, I have discussed several theories, developed in different epochs and domains, which provide a number of definitions and features of imaginative activity. The world imagination derives from the Latin word *imago* that holds several meanings (image, imitation, likeness, statue, representation, ancestral image, ghost, apparition, semblance, appearance, shadow, echo, conception, thought, reminder, depiction). All these ancestral meanings are still somehow feeding into the current definitions of imagination. Carl Gustav Jung (1959) directly used the original Latin term *imago*:

> to qualify a fact of experience as psychic and to suspend judgment with regard to its possible reference to any state of affairs in the so-called objective world, physical or metaphysical. (Heisig 1976, p. 91)

The idea of Jung was that of a psychological truth somehow overimposed to a real truth, with the imaginary production of a phantasmatic scheme (see the Aristotelian concept of *phantasma* as a product of imagination in Chap. 4) that becomes a guiding pattern in our interpretation of the Other. The epistemic function of imagination is still present, as the imago becomes an a priori in our experience of the Otherness including for instance the divinity (Heisig 1976), but it is still projected onto the opposition between the realm of reality and that of imagination.

The epistemic value of imagination is recognized as well by those definitions that consider imaginative power as a form of exploration, anticipation, or simulation. In everyday life and in scientific work, people guess, try to foresee different courses of future events, make hypotheses, and make plans. All these productions imply the capability of combining already existing elements and form new synthesis with the addition of new elements that cannot be necessarily inferred directly. However, they say that the products of imaginative work must be assessed *against* reality. Moreover, as Lapoujade (1988) noted, imaginative work is also setting the edges of reality, marking the horizon of experience and at the same time signaling

L. Tateo, *A Theory of Imagining, Knowing, and Understanding*, SpringerBriefs in Psychology, https://doi.org/10.1007/978-3-030-38025-0_6

the possibility of its overcoming, expanding the range of possibilities. As in the case of Hume's blue in Chap. 2 or in the example of the thought experiment, imaginative work makes visible what is not yet experienceable.

Together with the expansive function, imaginative work can also play an inhibitory function (Tateo 2017) of personal and social control (Fig. 6.1).

To a large extent, the inhibitory function of imaginative activity is well known in any religion. Figure 6.1 is an example of a very common religious genre in Christianity: the memento mori (remember you are going to die). The painting represents the classical theme of the death and the youth. The young pretty and happy girl on the left side is holding a flower, the symbol of beauty and life but also of caducity. The dead half on the right is holding an arrow symbol of the inevitability and sudden way in which death can strike in the midst of the flourishing of life. The cartouche at the top of the figure says: "*Remember, O Man, Look who you are/How unequal Dead and Alive are*." Since the Middle Ages, the memento mori figures

Fig. 6.1 Wall painting from the South Germany school, author unknown, eighteenth century, https://commons.wikimedia.org/wiki/File:Tot_und_lebendig.jpg

were widespread in churches, private and public places of gathering, cemeteries, etc. Their function was to constantly remind people of the fugacity of life and the necessity of living in preparation of God's judgment. One can hardly imagine nowadays the condition of a person living his/her entire life surrounded by these images of his/her own death, precisely because the contemporary Western societies are exorcising the idea of one's own death while producing images of war and catastrophes happening to the *Others* (Tateo 2019). Yet, the proliferation and internalization of memento mori could produce two exactly opposite but complementary responses. It was a powerful inhibitory mechanism of "sinful" conducts, or it could produce a strong encouragement to enjoy life exactly because of its ephemeral nature. Thus, the cultural artifact worked as mediational tool in the imaginative work to regulate real-life conduct. In other words, also reality must be assessed *against* imagination, both in its promoter and inhibitory function.

The current theories of imagination thus capture different aspects of this polymorphic and complex feature of human psyche. However, they fall short when they try to integrate imaginative activity with the other higher mental functions. The discussion makes it clear that it is necessary to go beyond the current definitions and to claim that the experience of the world without imagining would be impossible. Without imaginative activity, our world would be flattened on the here and now as that of a fly (von Uexküll 2013). Every individual weaves a web of relations with the properties of the surrounding things, which constitutes its world (*Umwelt*). This is the space of selected and secure perceived features in which the individual can manage to build effective responses. It is the realm of known paths of experiencing and action which is the result of personal elaborations. The limits of this web of relations mark what von Uexküll (2013) calls the borders between the *Umwelt* and the environment (*Umgebung*[1]). The ordering power of the individual is exerted on a selected part of the universe of discourse. What is outside the perception/action field constitutes a realm of uncertainty and danger, though still part of the environment. The peculiarity of the human beings is to constantly strive to explore the *Umgebung,* and incorporate it into the *Umwelt* through a transformative (and sometimes destructive) meaningful conduct. As I have discussed in Chap. 5 (see Fig. 5.3), humans do experience and know their world through a culturally mediated complementarity between imaginative and non-imaginative activity. The *Umwelt* is constructed from the subjective perspective of the individual, rich in both imaginative and non-imaginative overlapping features: in this sense, every personal world is "magic" (von Uexküll 2013). A very common experience, at home, is for instance to suddenly perceive a shadow or a sound in the peripheral perceptual areas. One has the feeling that some "being" has just run to hide behind a corner. One becomes aware of a sort of presence, although no visible trace is there. Of course, this is a trick of our perception, but after that, we keep a sense of uneasiness and alertness when we

[1] The term comes from the verb "geben" (to give) and the prefix "um." It literally means what is "given," outside the borders of the actively constructed world of the individual. It is what escapes the person, and at the same time what is there not because of the person. According to von Uexküll (2013), the surroundings are the opposite of the optimal Umwelt of the organism.

enter that room. von Uexküll (2013) calls this feature of the Umwelt, filled with exceptional subjective experience, *magic environment*s, and says that this kind of phenomena is common also in other animals, which suddenly begin to react against invisible presences in their *Umwelt*. Many sanctuaries posses this special feature, which is however a product of the culturally mediated subjective construction of the experience.

In Fig. 6.2, I try to summarize these features so far discussed, and to formulate my theoretical proposal about imagining and knowing. In Chap. 5, I used the term *universe of discourse*, to underline how in human *Umwelt* knowing is a web of symbolic relationships, of talking about and doing things with the world.

Thus, I define the production of new knowledge as the *complementary work of imaginative and non-imaginative activity, focusing on elements that go beyond the current limits of the universe of discourse*. People make sense of their *Umwelt* through the work of all psychic functions (thinking, imagining, remembering, feeling, and communicating), but when it reaches the limits of the personal bubble, on the edge of *Umgebung*, the hierarchy of functions changes and the role of imaginative work becomes even more important. Imaginative work is thus a crucial element in the emerging of novelty and in a qualitative breakthrough of the previous organization of the person/environment relationship.

One can create new knowledge, or a different understanding, about something which is already part of the universe of discourse (e.g., a new use of an existing tool or concept, like in the *ready-made* art). Moreover, new knowledge can emerge from the exploration of the *Umgebung* borders, or from the imaginative creation and overcoming of those borders (like in the case of the creation of an artificial limit to be overcome: e.g., a sport record or a status symbol). Imaginative incorporation of the environment and its borders creates non-imaginative self-regulation. The role of

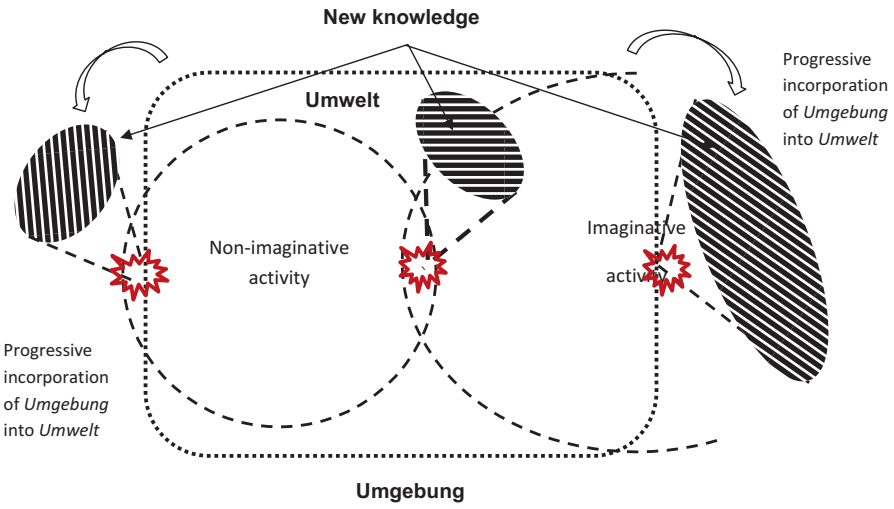

Fig. 6.2 Meaning-making and the imaginative/non-imaginative complementarity

imaginative work in human development is thus not only to explore the unknown, but also to produce the unknown as a driving force to be explored. It is not a matter of being "real" or "imagined." This opposition makes no sense in a theory of complementarity between imaginative and non-imaginative modes of knowing. The point is that the meaning-making process in human experience is always a complementary work of the two modalities that operate in the universe of discourse. Imagining is a higher mental function which is not building an alternative to reality; it is a fundamental process in the construction of human *Umwelt*. If the imaginative processes play such a crucial epistemic role, the next consequential question is this: Where do they come from? How are they ontogenetically formed in human beings?

Sociogenesis of Imagining

In the psychoanalytic approach, imagination is understood as the primary form of experiencing the world. The infant is a self-hallucinating creature, who lives his/her first days into a world based on the pleasure principle, in which imagination is the most direct way to feel satisfaction. In adult life, imagination will be used to satisfy personal desires, and to compensate an unsatisfactory reality: only the unsatisfied person imagines (Freud 1911).

For Piaget (1959), imagination is the subjective assimilation of reality to the egocentric satisfaction of the individual's ego. Only at a later developmental stage, facing the inadequacy of cognitive structures to the understanding of the reaction of the others and of the world, the child develops the capability of decentering itself from the egocentric perception and accepts the existence of multiple perspectives (Kohler 2018).

All the theories of human development link imagination to the ontogenetic process of acquisition of symbolic capability. This is why imagining is considered as a by-product of the development of symbolic processes. In the current understanding of human development there is a consensus about the fact that imagination in children is related to social processes, such as empathy and intersubjectivity (Papastathopoulos and Kugiumutzakis 2007; Toren 2012). In reality, we still do not know at what point in development the imaginative processes emerge. Vygotsky believed that imagination "does not develop all at once, but very slowly and gradually evolves from more elementary and simpler forms into more complex ones" (Vygotsky 2004, p. 12).

There is a general consensus about the fact that imagination derives from sensomotory schemes of exploration that develop first into imitation (Piaget 1959), then internal persistent imitation (Baldwin 1894), and then joint participation to activities (Vygotsky 2004). However, many of the criticisms to the understanding of imagination development address the fact that it is considered as an internal and individual activity, in which the external influences can only provide the raw material on which imagination operates (Papastathopoulos and Kugiumutzakis 2007;

Vygotsky 2004). Vygotsky (2004) claimed that the relationship between the individual and the context plays a crucial role in the development of imagination:

> We have seen that imagination depends on experience, and a child's experience forms and grows gradually, and, in its profound individuality, is different from that of an adult. The child's relationship to his environment, which, through its complexity or simplicity, traditions, and influences stimulates and directs the process of creation, is very different from the adult's. The interests of the child and the adult also differ, and it is thus easy to understand why a child's imagination functions differently from an adult's. (Vygotsky 2004, p. 31)

Apparently, we have a paradox here: If imaginative processes are a higher mental function that develops sociogenetically, through the progressive internalization of the individual participation to collective activities, how can it also be one of the child's first modes of experiencing, and a tool for the construction of the *Umwelt*? What comes first, the imaginative capability or the experience that develops such a capability?

Of course, this is only an apparent paradox. If one adopts the idea that imaginative and non-imaginative modes of experiencing are complementary in the construction of the personal world, and that they both develop through progressive internalization of social interactions, it is possible to conclude that they mutually feed into each other from the very early stages of development. This is the crucial point and at the same time the dark zone of the studies on the sociogenesis of imaginative processes. We do not know enough about the micro-genetic processes through which, day by day, persons construct their imaginative and non-imaginative ways of experiencing as epistemic tools. One should probably look at those micro-interactions in early development, during which adults prompt and suggest imaginative work to the children, much earlier than the symbolic play and the "as-if" interactions. Moreover, we do not know how the imaginative processes feed into the elaboration of non-imaginative processes. Vygotsky (2004) talks about the mutual feeding of reproductive and creative imagination, resulting in a real-life product:

> The imagination's drive to be embodied, this is the real basis and motive force of creation. Every product of the imagination, stemming from reality, attempts to complete a full circle and to be embodied in reality. A product of the imagination, which has arisen in response to our drive and inspiration, shows a tendency to be embodied in real life. The imagination, by virtue of the strength of the impulses it contains, tends to become creative, that is, to actively transform whatever it has been directed at. (Vygotsky 2004, p. 41)

In Chap. 4, we have seen how this feature of imaginative activity is fundamental for any form of scientific thinking, but also in other collective activities, such as religion. It links the capability to externalize symbolic meanings that in return guides our own psychic experience. From collective activities, one internalizes meanings that feed into the genesis of imaginative processes, which in return externalizes meanings that become able to produce effects into the world. When a parent begins a sentence with "imagine that X," he/she is producing a micro-event that leads to the internalization of different meanings of the verb "to imagine." A complete micro-genetic analysis of this process is still missing. The studies on imagining have mainly focused on the product of imaginative activity at a later age.

Educating Imagining

Why in the very end do we need to strengthen imaginative processes in science? After all, in the market economy knowledge is a commodity. It is thus subject to the laws of the creation of new needs in order to satisfy them with new products. Hence there is the push on creativity, innovation, groundbreaking, and breathtaking new discoveries in the academic work. On the other hand, the focus on evidence-based forms of science and technology reduces the space of imagining in science (Tateo 2014).

The point is that imaginative power in science is really needed nowadays. The myth of *Hippocrene* points to a very important element: the relationship between the *Muses* and *Pegasus* is the symbol of the unity of the different forms of human knowledge. Even though each of the *Muses* presides to one of the branches of human creation, they act as sisters and they all let inspiration from the spring of imagination. All the global problems that the Planet is facing in relation to human activities (e.g., fossil fuels, climate change, migrations, neoliberalist exploitation of resources) need innovative solutions (Bird et al. 2016). Human beings are instead stuck in the repetition of old solutions and acquired habits that inform world policies. Both scientists and decision-makers need a deep bathing into *Hippocrene*, in order to overcome the so-called science–practice, research–implementation, research–practice or knowing–doing gap (Bertuol-Garcia et al. 2018, p. 1033). Moreover, we can think of the myth of *Hippocrene* as the symbolism of an ecosystem on the top of the Mount *Helicon*. The *Muses*, the *Hippocrene*, and *Pegasus* have established a sort of coexistence in which natural resources, imaginative power, and different branches of knowledge prosper in harmony.

As I have tried to argue through the examples from the history of discoveries, imaginative work can become abductive evidence, able to orient whole fields of research toward new directions, as in the case of Moseley or Hawking. Imagining cannot be assessed against an a-historical ideal of progress in science. Like language and other higher mental functions, imagining is historically situated (Tateo 2015; Zittoun and Gillespie 2015) but not necessarily progressive. One cannot say that imagining in the past was *less developed* than today, as one cannot say that one language is less developed than another. Hence, there is the importance of using a source of knowledge like the myths to gain insight into problems.

A research program to explore the epistemic value of imaginative processes in science must be necessarily integrated by a pedagogical program. The first question is of course the following: Can imagination be taught? The answer is naturally negative. If imaginative processes are higher mental functions like language, problem-solving, and reflection, they cannot be transmitted, but can be *educated*. A pedagogy of imagination, based on research, should include the study of:

- Its historical and cultural forms
- Its ontogenesis and sociogenesis
- Its culturally situated practices and tools in sciences

- Its relation with other higher mental functions (e.g., memory, reflection, problem-solving) and with non-imaginative processes
- Its cognitive, affective, and ethical dimensions

If philosophy began with surprise, imagination leads us beyond the surprise, toward the *intentional production of surprise*, based on abductive forms of inference. The epistemic value of imaginative activity is exactly the potentiality for exploring new portions of the universe of discourse that have not yet been empirically reached. This is also the reason for imagination to be the first target of tyrants, markets, and orthodoxy. Hegemony needs to be evidence based, and needs to rely on the solid grounds of the best of possible worlds and on the reproductive imagination, as in advertisement and propaganda. Any systematic attempt to intentionally produce alternative worlds, to use the generative and productive imagination, and to play the "as-if" games (Vaihinger 2014) is looked with suspicious anxiety.

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Chapter 7
"*Don't Block the Path of Inquiry*": Imagination, Inquiry, and Knowledge

Maria Virginia Dazzani and Waldomiro Silva Filho

> *A concept is a symbol present to the imagination, — that is, more correctly speaking, of which a particular instance might be present to the imagination.*
> *Charles S. Peirce, The Basis of Pragmaticism in the Normative Sciences, Peirce 1906, p. 387*

Initial Remarks

1. Knowing the world around us, our own physical and psychological states and the people with whom we interact (their states and dispositions) are a condition of our existence. We do not exist as human beings if we do not have these (and other) forms of knowledge. And the word "know" here is taken in the prosaic sense that means being in such a cognitive state that it expresses a successful thought or belief about how things are. To find ourselves in this position, nature and society have given us some skills and abilities that, used properly, bring us closer to the truth and distance us from falsehood. Even if it is not possible to exclude the possibility of error and revision of our beliefs, we can consider that abilities and capacities such as memory, perception, and reasoning allow us to know the world in some aspects. In the same way, imagination, understood as a

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capacity to think beyond the data immediately available, to conceive possibilities, to infer regularities, is indispensable for us to know reality, both in common life and in the experience of science. This is because our cognitive experience is not only a table of records and representations, but also an inventive creation that integrates us as culture and society.

At least since Vico and Kant, there has been a lot of literature on the epistemic value of the imagination (Kneller 2007; Tateo 2016). Luca Tateo's essay *A theory of Imagining, knowing and understanding* (2), besides offering a comprehensive and concise explanation about the epistemic value of the imagination, advances in the sense of proposing a new vision about the imagination. For him, "imaginative process," "imagining," or "imaginative activity" is a fundamental higher mental function at work in everyday as well as scientific modes of thinking. In the dynamic process of ordinary life or in the laboratory, imagination plays a decisive role "to make sense of what happens, what happened and what will, should or must happen or, in other words, to generate judgments and plans about past, present and future." One of Tateo's main inspirations is semiotics. And one of his concerns is how these reflections can contribute to topics in general education and science teaching in particular.

2. In this chapter we will discuss a specific aspect of the theme explored by Tateo, that is, the role of imagination in the *process of investigation or inquiry*—the process of acquisition of new knowledge guided by curiosity, doubt, and search for truth—when we have, in the various spheres of life, a sincere question that longs for an appropriate answer. To this end, we will deal with the contribution of Charles S. Peirce, perhaps the author who explored in a more acute and inventive way how the imagination is constitutively present in the *inquiring process* (Misak 1991). This chapter does not intend to make an exegetical and "correct" study of the multifaceted work of Charles Peirce (Almeder 1980; Hookway 1992; Merrell 1997), but only to explore the sense that our inquiring experience (in common life and in science) is sustained both in past knowledge already symbolized, in our ordinary cognitive abilities (perception, memory, etc.), and in our capacity for imagination.

A Dweller in a Laboratory

3. "Thought is a sign": this is one of the maxims of semiotics. The description of the process of meaning is the first task of Peirce's philosophy. But the sign is not a simple code whose referent is an object (in the world) or an idea (in the mind). The sign is related to our ordinary involvement with the world (in its empirical occurrences, in the tradition of ideas and values inherited from culture), with other people, but also with the way this sign-thinking relates to other thoughts that conceive and interpret the world. But much of what we experience is in the realm of possibility, of novelty, of the unexpected.

C. S. Peirce considered himself the "inhabitant of a laboratory." His intellectual objective was to learn what he ignored, not to cultivate what the philosophers had already affirmed as infallibly true doctrines (cf. CP 1.3-4). This spirit of a laboratory man is a fundamental feature of his thought, but let us not confuse it with the "spirit of positivism" of the nineteenth century. Peirce, in fact, fought a battle against the traditional metaphysics and logic that, according to his opinion, was based on finished systems, enclosed in unquestionable truths that block the path of the true spirit of research. In one of his *Cambridge Conference Lectures* of 1898, Peirce suggests that philosophy creates some obstacles to the advancement of knowledge. Among them is the belief that this or that law or truth has found its last and perfect formulation and that the common and usual course of nature can never be broken (Peirce 1898, 48). As Aristotle had announced, human beings wish to know whether this is our primary impulse. Science, much more than a collection of safe knowledge and techniques, is an inquiry inspired by the desire to know ("*in order to learn you must desire to learn*"), so "*Don't block the path of inquiry*" (Peirce 1898, p. 48). For him, the human investigative spirit integrates *experiment* and *imagination*, combining a dose of objectivism with another of idealism to lead to the discovery of new (and surprising) aspects of reality.

4. In "Logic, Truth and the Settlement of Opinion" (Peirce 1872-73, p. 14), he wrote:

> The first condition of learning is to know that we are ignorant. A man begins to inquire and to reason with himself as soon as he really questions anything and when he is convinced he reasons no more. (…) Thus real inquiry begins when genuine doubt begins and ends when this doubt ends. And the premises of the reasoning are facts not doubted.

Thinking about the inquiry, the doubt/belief pair is really important. Doubt is an incitement to act, which has something of nervous irritation that the body tends to eliminate by reflex acts. Real and concrete doubt is an unpleasant and uncomfortable state that we try to get rid of in order to reach the state of belief; belief, in turn, is a state of tranquility and intellectual satisfaction. Belief is a disposition that directs action, and is a natural condition of the restless mind (CP 5.372).

The idea of semiotics as a philosophical logic seeks precisely to establish the laws of inquiry as a search to know what we do not really know.

Thought-Sign

5. As we know, Peirce's general theory of signs is a real labyrinth, mainly because Peirce has never published his work; what he has bequeathed to us is a (almost) chaotic set of fragments, unfinished projects, and incomplete works (Hookway 1992; Chiasson 2001). For the purposes of this brief commentary, we would like to highlight three terms—concepts that best understand the logic of inquiry from

a Peircean point of view. These are *continuity* (*synechism*), *interpretation*, and *representation*. And here we are obliged to face Peirce's somewhat exoteric vocabulary. The concept of synechism appears in texts such as "The Law of Mind" (Peirce 1892) and "Immortality in the Light of Synechism" (Peirce 1893): this expresses the idea that experience takes place in a temporal and spatial continuum that is open to the infinite representations that the human mind can create. Only in the light of synechism do the three famous categories of Peirce's semiotics, *Firstness*, *Secondness*, and *Thirdness*, make sense:

> … to secure to *Thirdness* its really commanding function, I find it indispensable fully [to] recognize that it is a third, and that *Firstness*, or chance, and *Secondness*, or Brute reaction, are other elements, without the independence of which *Thirdness* would not have anything upon which to operate. Accordingly, I like to call my theory Synechism, because it rests on the study of continuity. (CP 6.202)

The way the world gives itself to us (how it appears *signically*) and the way we interpret it depend on the *continuity* and relationship that our mind maintains with the world. To separate, on the one hand, the world and, on the other, our thinking about it would imply a discontinuity (as if there were a world-in-itself and a world-thought). The notion of *representation* here should not be confused with the traditional concept of representation, that is, the idea of an internal mental image over the external world. The representation was also named by Peirce as *representamen* or *expressiveness*: as a sign of *Thirdness*, the representation concerns that which is conceptual and discursive and which, in turn, is situated within the scope of what is intersubjective and belongs to the community of human interpretation.

In "Some Consequences of Four Incapacities," Peirce discusses about "representation" from the point of view of the notion of "sign in relationship" and from the following model:

> […] a sign has, as such, three references: 1st, it is a sign *to* some thougth which interprets it; 2d, it is a sign *for* some object to which in that thought it is equivalente; 3d, it is a sign, *in* some respect or quality, which brings it into connection with its object. (Peirce 1868, p. 38)

The sign expresses the dynamic and triadic sense of experience: our concepts, theories, interpretations, and discourses (which are part of the universe of *Thirdness* and the symbolic) would be empty without the functions of *Firstness* (the *continuum* of the world) and *Secondness* (the relations) (Merrell 1997, p. 118 e seg.).

6. The sign can only be conceived in the chain of interpretation when something is a sign-representamen that refers to something that is not itself, but an object that, in turn, is what determines another sign that interprets it (interpretant).

> A sign, or *representamen*, is something which stands to somebody for something in some respect or capacity. It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call the *interpretant* of the first sign. The sign stands for something, its object. It stands for that object, not in all respects, but in reference to a sort of idea, which I have sometimes called the ground of the *representamen*.

The *representamen*, while a sign of *Thirdness*, is that which is the object of an interpretation (can be a *proposition* or an *argument*). It is the *representamen* that is the theme of discourse, of an explanation, of a work of understanding, in short, of understanding and intersubjective experience. When we talk about inquiry, we are talking about the way our mind behaves in the continuous of the world in the effort to symbolize the experience—to make it part of the human symbolic universe.

Here comes the role of reasoning and argument as ways of conducting research. Peirce deals with this in order to talk about the way in which we are most likely to arrive at a secure knowledge of whatever we ask (Peirce, 1878). We would have three basic ways of representing every kind of inference, thought processes, or, as Peirce points out, three types of reasoning: *deduction, induction,* and *abduction* (Peirce, 1998, p. 225).

Abduction and Inquiry

7. Deduction and induction are forms of reasoning widely discussed in the history of logic and the theory of science. Peirce does not suggest that we abandon them; he just points out that they are not enough to describe the complexity of the flow of nature and, mainly, the way in which the imagination is able to construct an image of the world (without having all the data on how reality *actually* is). Peirce intends to broaden the view of the forms of reasoning and situate the deduction and induction in a broad process in which they are only a moment.

   Deduction or "*necessary reasoning*" is that kind of reasoning in which we start from a hypothetical state of things in which the events and objects of the world must *necessarily* occur in the way our thought conceives them (regardless of the way the universe is). Induction, on the other hand, consists of observing phenomena in order to see how closely they agree with a theory. It expresses the moment when thought seeks to confirm, gathering evidence and evidence, the fairness of a theory (Peirce 1903, p. 228).
8. As Merrell (Merrell 2004, p. 71) points out, *abduction* does not follow the same principles as classical logic. The logic of abduction is the logic of life immersed in the world, with all its indeterminacy and precariousness; it is a logic that embraces *inconsistency*, *incompleteness*, *uncertainty*, *complementarity*, and … *imagination*. Abduction is, above all, the term used by Peirce to name the cognitive-affective operation of the construction of an interpretation in which something can mean something. Abduction—also called alternatively hypothetical inference, retroduction, and hypothesis—plays a fundamental role in the processes of investigation or in the "logic of discovery." While "deduction proves that something must be" and "induction shows that something actually is operative," "abduction merely suggests that something may be" (Peirce 1903, p. 230). Abduction is only a hypothetical inference that makes an affirmation of something not yet experienced and enables us to formulate a general prediction without having the guarantee of a correct result.

Abduction is the process of forming an explanatory hypothesis. It is the only logical operation which introduces any new idea; for induction does nothing but determine a value and deduction merely evolves the necessary consequences of a pure hypothesis. (Peirce 1903, p. 230)

In some aspects, deduction and abduction are similar, since they share the fact that they have the general rule as an initial premise. However, abduction risks a hunch that is not based on the necessary reasoning: it is an imaginative invention based on experience.

Abduction admits surprise and misfortune, even if the human mind cannot avoid surprises and the incomprehensible. But Peirce, as Merrell insists (Merrell 2004, p. 81–2), suggests that not only in the laboratory, but also during every step in life, we are constantly using abduction, induction, and deduction. Because life is, precisely, the development of resolutions from surprises through the conception of possibilities (*abduction*) that we experience in concrete and physical life (by induction) to reach conclusion attempts (deduction). Within these processes, vague possibilities (*Firstness*) have become generalities (*Thirdness*). In other words, signs that are often inconsistent emerge (*Secondness*) and interact with other signs to engender sets of signs constantly turning into other signs to compose invariably incomplete systems of thought and action.

All this movement has as its starting point precisely an abductive thought constituted by creative acts of the mind. Even considering that deduction and induction guarantee less possibility of error, human experience suggests abduction as another way of deriving information, also responsible for the discovery of the new.

The Flight of Imagination

9. For Tateo (2020, p. 13, Chap. 2), "imagining as higher mental function implies some axiomatic assumptions: it is intentional, it is teleological and teleogenetic, it is a meaning-making semiotic process." This definition perfectly describes the meaning of abduction as a form of cognitive imagination. Abduction hypothesis occurs when we find ourselves face to face with an unexpected circumstance, but which can perhaps be explained by the assumption that it is the case of a general rule that we do not know about and that we cannot reach by induction (because we also do not know the criteria or the general rule that integrates this case with other similar cases):

> An Abduction is a method of forming a general prediction without any positive assurance that it will succeed either in the special case or usually, its justification being that it is the only possible hope of regulating our future conduct rationally, and that Induction from past experience gives us strong encouragement to hope that it will be successful in the future. (CP 2.270)

Even at the most elementary level of experience, what is at stake is a logical-abductive operation. Peirce wrote in one of his *Harvard Lectures on Pragmatism*: "The fact is that it is not necessary to go beyond ordinary observations of common life to find a variety of widely different ways in which perception is interpretative" (Peirce 1903, p. 242–243). Like any hypothesis, perception gathers all cases as "meaningful" (when we pass through a dark corridor and a shadow crosses our path, we can say "it's a dog," "it's a ghost," "it's a monster"; always; even if we are taken by terror, it will be something from which we infer the order … even if scared and deceived).

10. Abduction, while an inferential path, according to Peirce, is the first step of scientific reasoning and represents the attempt to design a system of rules of meaning, as a result of which a sign acquires its own meaning. It is in this framework that we take the imagination within the investigative process, feeding ways of thinking without which we would not know something new that escapes the schemes inherited by tradition. Abduction is so important that Peirce even states that the question of pragmatism is nothing more than the question of abduction, that is, the process of forming an explanatory hypothesis, being the only logical operation that introduces new ideas. As an inferential type of reasoning, abduction was necessarily invited to attend this discussion exactly because of its generative and creative character.

    The judgments on everything we have experienced carry out a mediation (in principle, revisable and, therefore, fallible) between the statement of facts and a general statement. Perception integrates semiosis and, therefore, is abductive because it can be corrected and, consequently, criticized. For this reason, the path of investigation is not lived only by the science of the laboratory, but also by all those who experience the continuum of time, space, language, and limits of life extension.
11. Perhaps the main lesson of Tateo's essay is that a conception of science education and teaching based on the Peircean conception of knowledge and mind should spur a specific logical goodness: a way of thinking that shows not only how things are or how thinking is guided normally, but also a logical good associated with invention, discovery, and uncertainty. From a pragmatic-semiotic perspective, there is no way to ignore that the "object of reasoning is to find, from the consideration of what we already know [belief], something we do not know" (Peirce 1877, p. 111).

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Chapter 8
Imagination in Science

Luana Poliseli and Charbel N. El-Hani

A Brief Overview of Tateo's Argument

The essay *Imagining, Knowing, and Understanding* from Luca Tateo defends the epistemic value of imaginative processes. To do so, he develops a dialogue between (i) Maria-Noel Lapoujade's (1988) philosophy of imagination, (ii) Dennis Sepper's (2013) history of imagination, and (iii) Leslie Stevenson's (2003) account of different ways to understand imagination, and his own works on epistemology, as he himself has a long history of defending imagination as a fundamental higher mental function, both in everyday and in scientific thinking.

In his essay, he describes imaginative processes as possessing some main features that can be summarized in the following propositions:

(i) Imaginative processes possess a generative capability to produce forms of knowledge, understanding, ideas, hypotheses, intuitions, anticipations, and simulations about oneself and the world one is part of, including both proximal and distal circumstances.
(ii) Imaginative processes imply a number of axiomatic assumptions, which Tateo derives from Valsiner (1994): it is intentional, teleological, teleogenetic, and a meaning-making semiotic process.

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The goal of the essay is quite interesting and ambitious, as it intends to explore the different ways we use imagination to make sense of what happens and how we use imagination when we are generating plans and judgments about past, present, and future, not only in daily lives but also in scientific endeavors. Tateo structures his chapter by (i) addressing some definitions of imagination (considering their implications and limits), (ii) presenting his own view on imagination, (iii) discussing the relation between imagining and knowing both in everyday life and in science, and (iv) introducing "some possible future (imaginative) pathway along which we can develop research about socio-genesis and pedagogy of imaginative processes that can become useful for both human and natural sciences."

In the *Introduction*, Tateo uses mythology as an important source of reflection as it can "signal the ancestral origin of some of the current philosophical, psychological, and existential problems." He departs from the myth of Hippocrene and the artwork of Joos de Momper il Giovane (*Helicon* or *Minerva's Visit to the Muses*) to show their association with imaginative power and different forms of remembering (both conscious and constructive, and unconscious and instinctual). Tateo explains how the Hippocrene is a place of inspiration not only for poetry but also for other forms of knowledge, such as history, mathematics, and astronomy. The persistence of the myth is seen by him as posing some fundamental questions: What is exactly the nature of imaginative power, insight, and inspiration that operate in knowledge construction? How are imaginative work and knowledge creation related?

In the sect. *5000 shades of imagining* the author brings three distinct examples (the book *50 shades of gray*, Hume's blue example, and the periodic table) to start presenting imagination not as a product, but as an activity. The idea of this section is to show that to view imagination as an activity is extremely relevant to understand the role of imagination in science. For instance, the author reminds us that imagination has been, since old times, understood as something in between the senses and the intellect: "It was the faculty of creating an afterward representation of sense impressions and providing a pre-worked material that could be stored in memory and used by intellect to work out ideas." But this reproductive imagination could also combine distinct images in such a manner that new images would emerge, say, three-headed dogs, dragons, mermaids, etc. Hume's blue example introduces then a different stance: an imagination that is not based on previous sense impression that is not reproductive; rather, it shows that imagination can produce genuinely novel ideas—it can be used in a generative way. In this example an idea is produced because of an absence, a gap. Thus, Tateo infers that the starting point for science is exactly "a gap feeling," an acknowledgement of a missing instance in the phenomenal world, and/or in our models and theories. Another example that helps defend this idea is Mendeleev's approach to the periodic table of elements, through a progressive unfolding of the table by filling the gaps. Thus, "gap feeling" leads to "gap filling."

Hume did not develop his experiment much further, yet the issue is extremely relevant to understand the role of imagining in science. According to Sepper (2013), in the presence of such kind of missing instances—no matter how many years of experience one has, how many shades are missing, or which sensory modality it is

about (colors, tones, patterns, rhythms, etc.)—one would start imagining the possibilities of filling the gaps.

Sometimes, however, it is the gaps themselves we are striving to understand. Gould (2002), for instance, invites us to consider the inhomogeneous population of morphospace. Morphological spaces, or morphospaces, are mathematical spaces that are central tools in theoretical and mathematical biology for describing and relating the phenotypic configuration of organisms (Mitteroecker and Huttegger 2009). In a typical morphospace, the morphological configuration of an organism is represented by a single point, and these spaces are not filled in all their points. Rather, they are heterogeneously populated by points and it is an important task in biology to understand why some biological forms never appeared in evolution. Historical and developmental constraints, for instance, offer explanations for why some forms never appeared, and thus for gaps in the morphological space. In this case, we do not move from "gap feeling" to "gap filling," but—one may say—to "gap understanding." This is an interesting case that may provide Tateo with fuel for further thought.

Imaginative activity plays an important role in scientific discoveries and explanations, especially—Tateo emphasizes—in investigating the connections between cause and effect. As an element in inquiry, imagining plays a role in different moments of the scientific process, and, despite the evocative nature of its characterization as "gap feeling" (or, for that matter, "gap understanding"), it requires more than that to be understood, as it is a tension toward something, not just an effort to fill in or understand absences. Thus, imagining is not only useful in identifying causal relations but also productive of new research goals: in other words, it is teleogenetic. Going back to Jacobus Henricus van't Hoff's 1878 lecture *Imagination in Science*, Tateo identifies several roles of imagination in scientific work, including the initial choice of a study object, how we alter the observed (say, through experiment), the development of instruments to facilitate or often even allow observation, the proposal of a hypothesis, and so forth. This is not just a procedural role in producing judgments as it also involves—again in van't Hoff's words—perseverance, affect, and passion toward the object of imaginative work.

In the section *Science driven by the power of imaginative work,* Tateo uses an interesting example from Brazilian history. He discusses how Brazil represented for Germans, both Nazis and refugees of Nazism, a sort of mythical land of opportunities during the 1930s, during Getúlio Vargas' regime, which was close to the German Nazi's regime. In the German imagination, Brazil was a sort of promised land, full of virgin territories waiting for explorers who could be able to take possession of a tropical empire. Thus, this section depicts how the public imagination of scientists and adventurers was used to gain support to undertake their trips to the Brazilian tropics and legitimize their professional careers.

The section *Imagination: a brief history of an unachieved definition* calls attention to some major reductionist misconceptions found in several definitions of imagination: (i) to address imagination as creativity and innovation (and, thus, the capability of researchers to provide groundbreaking discoveries) and (ii) to assume the imaginative act as a visualization of absent objects. Tateo puts under a critical

lens the traditional understanding of imagination as just the capability of organizing sensations in visual complexes or creating a simulation of the enactment of thought, which goes back to Aristotle's theory of mind, according to which whatever is in intellect was originally in the senses and there is no thinking without images. Rather, he asserts that imagination not only does come from sensations, but also goes in the opposite direction: from the inner mental work to the external reality, as a preparation to action in which the organism experiences an appetite for something. Imagination can be treated, thus, as *phantasia aistetiké*, a simulation carried out by the organism before being ready to act, which in fact increases its proficiency for action.

He considers the development of this traditional conception along two axes: on the one hand, imagination as the capability of creating visual representation of sense impressions and, also, of (re)presenting enacting and desires, which detaches the objects from their mental correlates, and on the other, imagination as located in the realm of dreams, visions, and precognition. The Vico-Descartes controversy is an interesting episode examined by Tateo. Vico assumes that imagination is an ancient form of knowledge, following a specific logic, namely poetic logic. In this sense, imagination is not opposed to rationality, but rather represents the ground on which rationality itself could develop along history. Vico and Descartes engage in polemics due to the claim of the latter for the primacy of mathematical rationality. The controversy can be seen as relevant nowadays, due to the fact that the latter form of rationality indeed became dominant in modernity. But, despite its usefulness in the realm of the natural sciences, it can be noxious with regard to the understanding of human nature. As Tateo argues, in this case we must rely on the fact that we share the capability of making our own social world, in which an understanding of others—a requisite for our proper functioning as a society—can only be achieved through the human capability to access the radical alterity of other civilizations (and, we add, cultures, people) through imagination. Tateo is right in recognizing Vico's anticipation in this philosopher's claim that the historically situated forms of human civilization cannot be understood by comparing absolute traits, but rather only by assuming the perspective of the other.

Two relevant features are identified by Tateo in the historical development of the concept of imagination: the intentional and the temporal nature of imaginative work. Even when we imagine the past, imagining is an intentional activity oriented toward the future. Also, imagination is not necessarily related to previous experiences, and in conceptualizations of imaginative processes their productive side has gradually become more important than the reproductive one. As Vygostky (Vygotsky 2004, p. 9) writes, imagination is a "human creative activity that makes the human being a creature oriented toward the future, creating the future and thus altering his own present," and as such it is the cradle of any human product. Nothing can exist in reality without existing before in imagination. Imagination relates abstract and concrete in both directions, as we can make concrete objects from abstract concepts or abstract concepts from concrete objects. This function of imagination is quite important for discussing the epistemic and pedagogical role of imagining in science.

In the section *Imaginative process and generalization*, the author introduces a thought experiment to defend the idea that even the most personal and intimate knowledge is complemented by imagination. Thus, so far we know from (i) Hume that empirical knowledge is complemented by imagination, and (ii) from Vico that knowledge of the alterity is complemented by imagination. Tateo strives, then, for exploring whether a role can also be ascribed to imaginative processes in abductive inference, abstraction, and generalization (see Tateo 2015).

In this section the author introduces an image to represent a phenomenological field with portions of the universe and potential generalizations. Importantly, Tateo highlights through this image that these portions cannot and should not be represented through perfect spherical bubbles, but rather should be taken as irregular shapes, because, as he explains, in our universe of discourse we are more sure about some things and less sure about other things. This introduces a key epistemological idea, readily appreciated from a scientific viewpoint (but not from absolutist stances), namely that our statements about the universe are held with different degrees of certainty. This is a key foundation for rationality, conceived as a specific attitude toward knowledge. Rational thinkers respect evidence when thinking about the empirical world. That is, evidence is a major (albeit not the only) justification for our beliefs about the empirical world. Accordingly, evidence can be regarded as a sign, symptom, or mark of truth (Kelly 2016), no matter how deflated. This is especially so if the rational agent does not accept evidence blindly, but rather is able to critically appraise the frameworks, methods, and interpretations that turn data into evidence. Every time we encounter new phenomena, the shape of the universe may change according to certain inferences we do with some tools, being evidenced in the case of the empirical world particularly relevant. But going beyond evidence, any form of new knowledge cannot be attained without the mediation of others or of specific tools. And, thus, despite evidence being so important, it is far from telling the whole story when it comes to accepting our statements about the world. However, evidence does tell an important part of the story. Importantly, these are, in our view, much-needed ideas in the current post-factual world, in our sadly post-truth times.

In the section *Thought Experiments and Utopias*, Tateo considers several forms of imaginative activity, like thought experiments, metaphors, and utopias in order to show the relevant role they play in scientific discoveries. What is explored are the different forms that the complementarity between imaginative and non-imaginative modes of thought assumes in scientific work. The author points out how imaginative processes play a role in abductive reasoning that may lead to the production of a completely new element, an overcoming of a current state of affairs, not just a recombination of existing elements in a creative way. Thus, the work of imagination sets the limits of knowledge and at the very same time denies those limits by offering a glimpse of their overcoming.

Tateo uses the last section of his text to put into question *why do we need a pedagogy of imagining*. He develops a cogent defense of why a research program exploring the epistemic value of imaginative processes in science must be necessarily integrated with a pedagogical program. Given the roles of imaginative processes in science, it is indeed of key importance to educate the imagination of scientists. This

may be a way to foster the education of scientists who go beyond technique and protocol, developing scientific work that opens up uncharted territories for our naturalistic understanding of the world and our experience in it.

Points for Dialoguing

We would like to raise some issues for discussion from Tateo's arguments. We expect to bring points for dialoguing that might eventually lead to some agenda for future interaction. Let us begin by posing some questions that we regard worthy of further exploration. Later, we will highlight some connections of Tateo's arguments with developments in philosophy of science and intercultural communication.

Questions

The first issue concerns some concepts and definitions throughout Tateo's text. One of the paramount arguments of the author is that imaginative processes possess several distinct outcomes, such as *knowledge, understanding, ideas,* and *hypotheses.* However, they are neither defined nor characterized. For instance, the distinction between knowledge and understanding has been an important matter for epistemology and philosophy of science. Contemporary investigations have acknowledged their distinction, the first one being defined as justified true belief and the second as cognitive achievement. Such distinctions allowed for investigations regarding the nature, assessment, and achievement of understanding (see Kvanvig 2003; Pritchard 2009; Greco 2014; de Regt 2017). Once we assume the dissimilitude among their products we can consider that higher mental functions might achieve those products through distinct strategies. Thus, how are "knowledge," "understanding," "ideas," and "hypotheses" to be defined and distinguished from one another and how are they to be assessed? Moreover, if we use our imagination in everyday life and also in scientific activities, will there exist any differences between the imagination processes that occur daily from the ones in scientific thinking? If such differences exist, what would they be?

The author asserts that the universe is shaped according to our contact with phenomena and, thus, the mediation of tools in encounters with unfamiliar objects provides an interesting way to understand how we can become more certain about portions of the universe of discourse we barely know. We would like to draw attention to two issues in this argument: (i) to the uncertainty of the terms *universe, universe of discourse*, and *portions of the universe*. It looks like the term *universe* and its derivatives possess different meanings in this metaphorical usage, for instance, discourse, perception, phenomena, ideas, images, hypotheses, and so on. How are they distinguished from one another? (ii) How exactly the tools mediate

the relations with the objects? Perhaps a clear concept of mediation would do a nice theoretical work here.

When the author discusses the tools in everyday life but also in scientific inquiry, he uses the following quote: "We then turn to others in order to strengthen our knowledge about the different parts of the portion of the universe of discourse, involving the socially organized form of intersubjectivity and interobjectivity we use to call scientific inquiry (Tateo 2015, 58)." Well, not always. Nonacademic actors can inquire about different parts of the universe in an approach rather different than scientific inquiry, turning to others in importantly different ways, and yet strengthen knowledge about different portions of the universe of discourse. Indigenous knowledge is a clear case in point.

In the section *Thought experiments and utopias*, we were intrigued by the definitions Tateo uses for these terms. For instance, he defines a *thought experiment* as a complementary work of imaginative and non-imaginative activity focusing on a specific problem that goes beyond the current limits of the universe of discourse. But if the thought experiment focuses on a specific problem, does it necessarily have to go beyond the universe of discourse? Couldn't it go deeper and deeper into the universe of discourse? The second term, *utopia*, is defined as an activity (thought experiment, perhaps?) that focuses on a whole universe of discourse. It is really difficult to grasp this distinction if we do not have at hands a clear understanding on what "universe of discourse" means. For instance, we can have a thought experiment in the realm of physics (say, Schrödinger's cat experiment) that can represent a whole universe of discourse, but at the same time a very specific context.

In the same section, Fig. 1.5 includes imaginative and non-imaginative activity. But what are non-imaginative activities? The examples used to explain non-imaginative work all come from scientific activity, but the author cannot assume that scientific activity lacks imagining, since this would contradict a major thesis of his work. Thus, more needs to be said on what are non-imaginative activities and how they appear in domains other than scientific work.

Tateo also stresses several strategies for imagining—from thought experiments to metaphors and utopias—all of them in a future-oriented way. If the goal is to bring imagination into science, Tateo brought a great example on how Brazil was depicted by the Germans as a wild refugee for the Nazi party through the use of books and movies in the 1930s. We already know that societal thinking can be modeled by literature, poetry, and movies, as it was the case of *Frankenstein: or the Modern Prometheus*, *Brave New World*, *Dr. Strangelove or: how I Learned to Stop Worrying and Love the Bomb*, etc. We are curious, however, about the possibility of the opposite to happen. How can science take advantage of a dystopic and counterfactual scenario to produce knowledge, understanding, hypotheses, and ideas? This might illuminate in some sense how imaginative processes can work teleogenetically.

Finally, it is clear that there is much more to say about the proposed "pedagogy of imagination," a much evocative idea. But, surely, this is work in progress by Tateo himself.

Connections

Imagining and Understanding

In contemporary epistemology, understanding is defined as a cognitive achievement (Pritchard 2009), and in recent debates in philosophy of science scientific understanding is considered as "an epistemic and cognitive skill reached when the scientist is capable to develop intelligible explanations (and sometimes derive predictive counterfactual scenarios) about the phenomena" (de Regt 2017, xx). According to the contextual theory of scientific understanding (de Regt 2017), the more intelligible an explanation (or hypothesis, argument, theory, model, etc.), the better are the chances for the scientist to understand it. In this sense, there exist conceptual tools (unification, causal explanations, visualization, visualizability, etc.) that help enhance the intelligibility of an explanation and, therefore, the chances for the scientists to grasp it. We suggest that imagination can be connected with scientific understanding in two ways: (i) by means of the conceptual tools of visualization and visualizability (de Regt 2017) and (b) through the use of intuitions by the scientists (Poliseli 2018, 2019).

First, De Regt (2017) suggests that there might exist a link between visualization and understanding, and between visualizability and intelligibility. Visualization is regarded as a useful guide to achieve scientific understanding, while visualizability is a theoretical quality that may enhance intelligibility. Visualizable theories are often regarded as more intelligible than abstract ones, because many scientists prefer visual reasoning in the construction of explanations for phenomena, using pictorial representations or diagrams as tools. Examples include Richard Feynman's diagrams and Erwin Schrodinger's defense that the only way to acquire understanding of nature is to build theories visualizable in space and time (de Regt 2017).

Second, by observing a scientist developing an explanation and constructing a mechanistic model, Poliseli (2018, 2019) and Poliseli et al. (2019) described that much of the scientist's practice of explanation construction was based on the elaboration of sketches and diagrams, while the achievement of understanding relied strongly on intuition. By intuition, Poliseli refers to the elaboration of mental models and thought experiments that allowed the scientist to depict qualitative and predictive scenarios for the phenomenon in question.

Both of these examples are in agreement with what Tateo proposes when he asserts that "once this reproductive faculty has created mental images, these can be recombined in numerous ways to originate infinite new combinations." Thus, even though imaginative processes can work in scientific contexts, there is still need for future investigations to answer questions such as the following: Is it imaginative work at stake only in the context of discovery or also in the context of justification? In what sense can we consider imagining as a sort of epistemic virtue?

Imaginative Processes and Models as Mediating Epistemic Artifacts

A relevant connection between the discussion on the epistemic value of imaginative processes and developments in the philosophy of science concerns the pragmatic views on theories. Along the twentieth century, our perspectives on theories (and, also, models) changed in important ways, from the syntactic view associated to logical positivism, through different versions of the semantic view, up to the current trend toward pragmatic views (for a good review, see Winther 2016; for a review in relation to modeling-based science teaching, see Gilbert and Justi 2016). We do not have the space here to review this history; rather, we will focus on recent developments that show a clear relationship with the discussion on imaginative processes in scientific work.

Among the philosophers advocating a semantic view of theories, we find authors, like Giere (1988), who introduced a less formalized understanding of the relationship between model and reality than the one found when primacy was ascribed to mathematical structure when explaining models. This leads to a more flexible understanding of the representational relationship between model and reality. For Giere, for instance, a model should show properties that are *similar* to the target system or object. He appeals, thus, to a relation of similarity, distinct from the mathematical isomorphism required by other advocates of the semantic view (e.g., van Fraassen 1980; Suppe 1989) and close to an idea of resemblance. It is important, then, to further specify this vaguer notion, but this is not done by proposing some overarching definition of similarity. Rather, the nature of the representational relationship appealing to similarity is to be fixed by the agents who build models. As Giere writes (Giere 2004, p. 748), similarity can be broadly conceived as "the existence of the specified similarities that makes possible the use of the model to represent the real system" in a certain way.

A key development in this trend in semantic approaches lies, then, in a shift from dyadic views on modeling, concerned with the relationship between the model and its target system, to triadic views, also considering agents such as model developers and users, and thus going beyond an analysis of model and system structure (e.g., Morrison and Morgan 1999; Giere 2004; Bailer-Jones 1999, 2009). Under this light, a model still has a representational relationship to a target system, but a key role is ascribed to the purposes assumed by an agent when developing or applying the model. The agent specifies which similarities between model and system he/she intends to seek and for what purpose (Giere 2004). These are appealing ideas as evidently no model represents by itself; rather, representation occurs when the model is used by some agent for some specific goal. This is a consequential shift as it replaces the notion of a "model of something," stressing how models represent the world, by the notion of "model for something," laying emphasis on how models are used to represent the world (Knuuttila 2005a).

Pragmatic views emerged from this trend, stressing that to understand models is to understand how they are used. A key idea then is that models are not merely used as representations. More than just representing, models are used as complex and plural structures that work as tools for investigation and learning, fulfilling diverse

epistemic functions in scientific knowledge production. Furthermore, models allow us to investigate and learn not only about the world, but also about theories themselves. Thus, how could models be seen as just representing the world from the perspective of a given theory? Something else seems necessary to understand how models work.

Knuuttila and Voutilainen (2003, p. 1485) express the difference between semantic and pragmatic approaches as follows: while the adherents of the semantic view treat models in science as more or less steady and as ready-made entities, the proponents of the practice-oriented approach (or, as we call it here, pragmatic) are interested in the modeling process and try to explain why and how models are used in scientific endeavors.

Among the advocates of the pragmatic view, Morrison and Morgan (1999) are well known for their proposal that models work as *mediators*. In this *mediation* view, as dubbed by Gilbert and Justi (2016), models are seen as partially autonomous agents that mediate the relationship between theory and reality (or experience). Therefore, while model builders and users are agents, models themselves are also treated as agents, becoming a key issue to understand how these agents interlock in their agency and purposes. Moreover, models are regarded, as mediators, as partially independent from both theories and reality (Cartwright 1983). They are not entirely derived from data obtained from reality, but they are not also entirely derived from theory. They are produced by using both data and theory, but also other elements, such as metaphors, analogies, political views, values, creativity, and rules of thumb (Boumans 1999). They are also tested through evidences that are not merely data, but are constructed from interpreting data under the light of theory.

The partial autonomy of models makes it possible, according to Morrison and Morgan (1999), for them to work as inquiry tools in scientific practice in a variety of ways, for instance, in measurements, experimentation, analyses, and technological production. Models suggest ways of learning about theory and reality, and, thus, they become also (partially) autonomous agents that drive our efforts—as agents—to investigate and learn about both reality and theory. The value of a model is not related, from this perspective, to the extent to which it is an accurate representation of its target (as in the semantic views), but to its performance when used as a tool for investigation and learning in specific contexts. Rather, for certain purposes a model may need to show some degree of representational inaccuracy in order to be useful (Morrison 2007).

More recently, Tarja Knuuttila (2005a, 2005b, 2011) went a step further in the pragmatic perspective. Based on Morrison and Morgan's claim of autonomy and mediation as characteristics of models, Knuuttila proposes a new way of understanding models, dubbed by Gilbert and Justi (2016) *artifactual*, in which models are materially interpreted as epistemic artifacts always embodied in some material means. The mediation view, according to Knuuttila (2005b), makes it possible to elaborate a view of models as things made by humans, artifacts developed using a variety of ingredients, which are manipulated for some purposes, especially to gain knowledge in diverse ways.

To see models as artifacts does not entail that they should be concrete objects, just that models are expressed in some representational means external to the subject, which favor manipulation. These representational means can be physical structures, but also abstract objects, equations, symbols, graphs, etc. In a diversity of representational means, they can participate in cognitive processes in equally diverse ways, scaffolding our imagination on how systems can be, behave, and interact.

Knuuttila also deflates the role of representation in model evaluation, and goes beyond Morrison and Morgan, claiming that models are fully independent of target systems in the real world, rather than just partially independent from theory and data. Granting models the status of independent agents is a requisite, in her view, to understand how models enable us to learn through producing and using them. We generate knowledge by producing and using models; that is, knowledge building is performed by us through modeling, and this would demand such independence from the real world. To interpret what she means, it is important to consider that knowledge building through modeling is a complex process in which representation—in which the model-reality relationship becomes central—may be involved, but many other actions should be performed. If we treat models as epistemic artifacts—Knuuttila (Knuuttila 2005a, 2005b) argues—we can ascribe to them several functions besides representing, recognizing that models are not only tools for representing, but are often also productive.

From the mediation and artifactual views, it naturally follows a focus on modeling as an activity. Modeling is a mediating and creative activity involving objects, process, and ideas, and its key practices are productive in nature, and dependent on which model—with which structure—is needed for which purpose. When modeling, scientists should not be constrained by reality throughout, perhaps not even mostly, as modeling demands diverse kinds of inferences about the target, such as abstraction and, often, also simplifications and idealizations, and typically involves non-direct observable objects or processes, which are conceptually imagined and sometimes can be even fictional.

The links between model and reality are more complex than expressed merely by the idea of representation (Knuuttila 2005b). Again, we find the view that a model is not evaluated through its representational power, as claimed by semantic philosophers, but rather—from a more pragmatic perspective—through its successful performance when dealing with the specific tasks to which it was constructed and/or put to use (Knuuttila 2011). A model shows a good performance from this standpoint, when it is a successful external artifact to support thinking and/or when it is manipulated in the performance of epistemic and applied functions.

This view on models, which is probably the most accepted today, highlights the role of imaginative processes in science. An important if not the most important task in science is modeling, and given that modeling is a creative activity, generative of new meanings, not just reproductive, it is clear, also from this perspective, how central imagination is for scientific work. Moreover, this argument also contradicts mechanical views of scientific work, committed to the myth of a supposed scientific method composed by a linear sequence of steps. Scientific work is (or, at least, should be) anything but mechanical; rather, it is a fundamentally creative

activity, and the role of imaginative processes clearly shows this aspect of scientific practice. Imagining and knowing, as Tateo discusses, are fundamentally related in the workings of the human mind. Science is no exception. The construction of scientific knowledge involves an interaction among methodical and systematic work, insight, inspiration, and imaginative power, and perhaps nowhere in scientific work can this be more readily seen than in modeling. The role of imagination in science shows how detrimental is an education of scientists that is limited to technical knowledge, training scientists as just manpower to business-oriented discovery rather than to the creative task of building an understanding of the world. We wholeheartedly agree, thus, with Tateo's advocacy of an education of future scholars that takes into account the epistemic value of imagination, and thus gives imaginative work a much more central role than we find in current technical driven education of new scientists.

Key passages in Tateo's chapter highlight this connection between his discussion of imaginative processes in science and the pragmatic understanding of modeling as a mediating and creative activity that produces epistemic tools—models—that go beyond theory and data, and, by being so, provides us with a much effective tool for investigating about both model and reality. For instance, Tateo describes imagining as linking and mediating between empirical and conceptual, striving to overcome the borders of the phenomenal field and constantly displacing its center, and as mediating between sensibility and intellect, setting the limits of human experience while at the same time showing the possibility of transgressing them. This is evidently much consistent with the idea of modeling as a creative activity mediating between theory and reality, as well as with the idea of models as tools for learning more and more about the phenomenal world.

Tateo also describes imagining as a "synthetic faculty, organizing, mediating, integrating and rotating the elements of senses," but which has also a "transcendental function" that, surprisingly, makes the very empirical intuitions possible. As Lapoujade (1988, 80–81) writes, imagination "marks the limits of possible knowledge. Human knowing reaches as far as imagination goes […] imagination eminently plays a mediation function, as it presents a double face: one looks to sensibility, through which it works; the other looks to understanding, accepting its rules in the epistemic processes" (Tateo's translation). This double face of imagination, as explained by Lapoujade, can be fruitfully connected to our understanding, with the mediating role of models between theory and reality, which can only be played by their transcendental function, as tools that are independent from both theory and reality, according to Knuuttila.

The necessary involvement of imagination in modeling is also clear in McAllister's (2012, p. 11) claim quoted by Tateo, stating how scientists use imagination when they conceive possible features of the world that they have not previously encountered empirically, positing unobserved, unobservable, or nonactual states of affairs. As Tateo sums up, this may show how science is not just a matter of filling gaps, but also of feeling gaps, an interesting metaphor that may also harbor the role of understanding gaps, like those in the morphospace of living forms.

He also asks whether imaginative work is involved in generating hypotheses or also in their testing. It seems just as interesting and fruitful to ask how imagining participates in modeling, and what are the consequences of this participation.

Imagination, Knowledge Integration, and Intercultural Empathy

Another relevant connection evoked by reading Tateo's paper concerns the idea of intercultural communication, with which we deal in our transdisciplinary work on integrating traditional and scientific knowledge in education and conservation. Tateo argues that a "common understanding of human beings" can be achieved "through the human capability to access the radical alterity of other civilizations through imagination" (Tateo 2016). In the current chapter, he argues, "we can come to know what people in other times or other places of the world can think only if we start by imagining how it could be to live in their way," and echoes Vico's claim that the forms of human civilization can only be understood by assuming the perspective of the other. Here, we would like to introduce some caveats concerning two ideas, namely that of "common understanding of human beings" as a goal, and that of assuming the perspective of the other as a way of mutual understanding.

The first idea puts too much emphasis, to our understanding, on the possibility of combining the ways human beings understand the world and, thus, tends to downplay the important divergence between our worldviews and cultures. This is of central importance in the discussion of knowledge integration, which has become increasingly important as we focus more and more on transdisciplinarity, coproduction of knowledge, comanagement, and other key concepts in fields as diverse as conservation, anthropology, and education (e.g., Schnellert et al. 2008; Gavin et al. 2015; Wolverton et al. 2014). We will tackle our first caveat, then, from the perspective of our own treatment of knowledge integration in the context of the transdisciplinary projects we carry out in fishing villages in the north shore of Bahia, Brazil, more specifically, in the Itapicuru Estuary, Municipality of Conde, aiming at transdisciplinary work in intercultural education and community-based conservation.

Transdisciplinary approaches based on collaborative and integrative perspectives raise complex philosophical problems concerning the prospects and limits of knowledge integration. These problems can be summarized as four challenges (Ludwig and El-Hani in press): (i) the epistemological challenge following from the fact that traditional communities (or, for that matter, most if not all people in other times or other places of the world) and academically trained scientists use quite different methods to produce and validate knowledge (see, e.g., Wilson 2008); (ii) the ontological challenge raised by the diversity of assumptions about reality and the categories composing it, as shown, for instance, by anthropological studies on the mental lives of plants and forests (Kohn 2013) or on the status of rivers as persons (Hutchison 2014); (iii) the ethical challenge following from the fact that these different epistemic and ontological assumptions are intertwined with differing value systems, for instance, distinct ways of ascertaining the moral responsibilities of human and nonhuman agents (e.g., Anderson 1996; Berkes 2012; Wolverton et al. 2016); and

(iv) the political challenge resulting from the fact that distinct stakeholders are often in quite different power positions, and, thus, differ in the strength in which they can enforce their epistemological, ontological, and ethical perspectives in collaborative practices (Nadasdy 1999, 2005; Ludwig 2016).

If we take these challenges in due account, we may suspect of two perspectives often found both in the literature and in practice (see, e.g., Ludwig 2016, for discussion): on the one hand, excessively optimistic proposals of knowledge integration, as one often finds in the field of conservation, and on the other, pessimistic positions on knowledge integration that dominate the anthropological field. While the first position seems tributary of a philosophical universalism that tends to assimilate other forms of knowledge into scientific knowledge, only integrating pieces of traditional knowledge that are not at odds with the scientific perspective, the second seems committed to philosophical relativism, overplaying the incommensurability between knowledge systems. Our caveat concerning the idea of a "common understanding of human beings" arises from the fact that we think that this goal is dangerously close to a philosophical universalism that tends to downplay the important differences between the epistemological assumptions, ontological views, and value systems that emerged from distinct sociohistorical conditions, as interwoven aspects of human symbolic cultures. But what option is available if one wants to navigate between the Scylla of universalism and the Charybdis of relativism?

In contrast with these two perspectives, a methodology of partial overlaps can be introduced (Ludwig 2016; Ludwig and El-Hani in press) that allows for a via media between excessive (universalist) optimism and (relativist) pessimism concerning knowledge integration. We can describe the perspective of such a methodology as that of a critical optimism. On the one hand, this is important because emphasis on optimistic views on integration tends to obscure differences between stakeholders and reproduce hierarchical positions often taken by scientists and local communities (Nadasdy 1999, 2005). On the other, too pessimistic views appealing to radical alterity and sheer incommensurability tend to be equally problematic, both theoretically and politically (Ludwig and El-Hani in press). Theoretically, this is because the very idea of entirely incommensurable knowledge systems has been challenged in its coherence (see Putnam 1981; Davidson 1984). Politically, an advocacy of full incommensurability among knowledge systems would entail the risk of undermining the possibility of any productive interaction between heterogeneous stakeholders, ultimately reinforcing the "divide between Indigenous and scientific knowledge" denounced by Agrawal (1995), which brings with it an assumption of insurmountable differences that can marginalize traditional knowledge in policy and practice (Hunn 2014).

A methodology of partial overlaps provides a more nuanced perspective that gives support to an attitude we can call "intercultural," in which scientists become reflexively aware that scientific knowledge is one knowledge system among many produced by mankind along history, but without assuming a relativist position. Relativism is avoided if we derive from the fact that any knowledge system has developed in specific cultural and historical circumstances the outcome that there are particular sets of issues in the relationships between humans and nature to which

each knowledge system lends itself better, as a form of cultural adaptation. From the differences between knowledge systems, one does not draw then the conclusion of sheer incommensurability and otherness, but a commitment to intercultural dialogue, which follows from the judgment that both science and local communities can benefit from comprehensive interaction (for a nice discussion of the intercultural attitude, see, e.g., Rist and Dahdouh-Guebas 2006).

The arena where intercultural dialogue can emerge can be delimited, thus, from an analysis of overlaps between knowledge systems that offer grounds for collaboration and mutual learning and understanding. These overlaps may concern knowledge in itself and/or the epistemic, ontological, and value assumptions grounding its construction and validity judgments. Intercultural dialogue cannot be carried out, however, in denial of the important differences in knowledge and epistemological, ontological, and value assumptions among knowledge systems. That is why the partiality of overlaps is a key aspect to be considered, demanding from the researcher a normative and political position that we derive from the intercultural attitude. All these aspects show how one needs to go beyond seeking a "common understanding of human beings" when dealing with interculturality. Surely, this does not detract from a role to imaginative processes in intercultural dialogue, but contributes to recognize how complex is this dialogue, and how it should involve more than imagining the perspective of the other in search of commonalities. This leads us to our second caveat.

It concerns the idea that we can know how people in other times or other places of the world think by assuming the perspective of the other, by imagining how would it be to live in their way. This seems committed to an interpretation of intercultural understanding as dependent on a sort of psychological empathy. This latter idea has been questioned, however, in the literature on intercultural communication, and from this critical perspective it seems likely that we can learn more on the role of imagination in building an understanding of others.

Intercultural empathy is a controversial construct in the literature on intercultural communication (e.g., DeTurk 2001). If we look at conceptualizations of empathy, we will see that many of them come from psychology and counseling, treating empathy as a personality trait, as diverse forms of ability (e.g., the ability to accurately predict internal states of others, to assume the role of others in cognitive terms, of communicating so as to reach a sense of understanding of the other), and as emotional identification (Broome 1991). These psychological renderings of "empathy" are, however, problematic for tackling intercultural situations, due to obvious difficulties of accurate perception and/or assuming the role or place of the other. If it is not evident how we can put ourselves in someone else's shoes when we share the same cultural background, it is even less so when we are considering people coming from other sociocultural realities. This difficulty initially led to attempts to propose definitions of empathy specifically linked to abilities for intercultural communication, such as Hammer's (1992, cited by DeTurk 2001, 375) definition of empathy as "the ability to understand the other person's message from that person's perspective," or Klopf and Park's (Kopf and Park 1984, 112) rendering of this ability as that of trying "to become one with the other by projecting one's own

personality into the personality of the other person", thus attempting "to see things from the other person's frame of reference." However, these attempts are still limited, due to their reliance on our supposed ability to project ourselves into the other, or the other into ourselves, which are clearly at odds with the private nature of our subjective experience (see, e.g., Kim 1996).

An important advance toward an understanding of empathy apt to deal with intercultural situations was made by Bennett (1979) in his criticism of the so-called Golden Rule: "Do unto others as you would have done unto you." As he argues, this rule is committed to a similarity assumption, namely that others are just like us and want to be similarly treated. However, this implies the idea of a shared absolute sense of reality, even a commitment to ethnocentrism. Bennett proposes, then, that we replace the Golden Rule by what he calls the Platinum Rule: "Do unto others as they themselves would have done unto them." From this perspective, empathy cannot be seen as just a psychological construct in which we project either ourselves into the other or the other into ourselves. Rather, empathy becomes fundamentally participatory, or, in Bennett's words, empathy is "the imaginative intellectual and emotional participation in another person's experience" (Bennett 1979, p. 418). This is an important change, as we shift from an internalist perspective on empathy to a communicational, interpretive, and interactional view. Empathy comes to be seen as a phenomenon situated in relationships among individuals, rather than in individuals per se. This situated, relational approach to empathy can be quite important, then, for intercultural communication.

Broome (1991) elaborates on relational empathy departing from Bennett's perspective toward a participatory and situated account of knowledge and meaning, according to which they do not exist before communication—as usually conceived in Western thinking—but emerge through (communicative) social interaction, being co-constructed by individuals interwoven in relationships. The kind of mutual understanding envisioned in the concept of "empathy" should emerge, thus, from relationships. Empathy is necessarily relational, and, as such, does not emerge through one's supposed ability to put oneself in someone else's shoes; rather, it emerges in the relationships themselves, as a "third culture," to use Casmir's (1999) expression. Empathy is not had by anyone, but it comes to be in between individuals. The dialogical notion of betweenness as belonging to the nature of empathy can be framed by the idea of a "third culture" that can be understood, supported, and defended by all who shared its development, that is, who worked together in "the construction of a mutually beneficial interactive environment in which individuals from two different cultures can function in a way beneficial to all involved" (Casmir 1999, p. 92). It can also be framed by a social constructionist perspective according to which knowledge is not something that people have in their heads, but is something that people do together (Gergen 1985).

Relational empathy can play a rather important role in co-construction of knowledge and understanding through transdisciplinary processes. This comes to the surface when we ask what should we do when several stakeholders who are working

together to co-build knowledge, co-manage practices, and so forth find the partiality of the overlaps among their knowledge, worldviews, epistemic assumptions, and value systems? How can we share and participate in the experience of one another when cognitively we face limits in our mutual understanding? Relational empathy may well be an answer. Meaning-productive relational empathy, as envisioned by Broome (1991), may emerge from a participation in the experience of one another that is not only intellectual, but also—and fundamentally—affective, making it possible to coexist and co-learn despite radical alterity. And just as it emerges from shared experience, relational empathy feeds back onto the maintenance of the sharing, on preserving the joint experience that maintains itself. Far from detracting from Tateo's and others' idea that imagination plays a role in intercultural understanding, relational empathy liberates this idea from a reading of empathy as a psychological internal state that may be lurking behind the understanding of imagination. After all, relational empathy is fundamentally imaginative. It is no coincidence that Bennett characterizes empathy as an "imaginative intellectual and emotional participation in another person's experience"!

Concluding Remarks

We hope that these questions and connections can be helpful to Tateo's future development of his insightful and theoretically sound ideas, in one way or another, and, also, that fruitful shared experiences of co-learning emerge from this initial exploration of his work. We may have much to do in order to understand the complementary epistemic pair of imaginative and non-imaginative work in science, which may indeed lead to a whole new set of theoretical and empirical research in epistemology, as suggested by Tateo. But the understanding to be sought goes beyond epistemology, as imagination is also lacking in how humans are facing the global problems following from their activities, such as climate change, mass extinction, and loss of environmental services. As Tateo writes, "human beings are (…) stuck in the repetition of old solutions and acquired habits that inform world policies." We need more than repeating old solutions, however, as the challenges we face need our reinvention as glocal citizens who share the globe from our local lives and, thus, should go beyond our local lives and interests if we wish to survive (or, at least, survive with some lasting quality of life).

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